AN OGDEN PUBLICATION DEVOTED TO GLASS TECHNOLOGY, ENGINEERING, MATERIALS AND GLASS FACTORY EQUIPMENT AND OPERATION

the glass industry

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Published by

OGDEN PUBLISHING COMPANY 55 WEST 42ND STREET, NEW YORK 36, N. Y.

JOHN T. OGDEN, Publisher
CYRIL B. DELGADO, Editor and Business Manager
KATHERINE A. HOWE, Production Editor
J. A. TEDESCO, Circulation Manager

Midwest Representative: Macintyre-Simpson & Woods
Chicago office: 75 East Wacker Drive
Cleveland office: 1900 Euclid Avenue

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The GLASS INDUSTRY, Vol. 35, No. 12, December, 1954. Published monthly by Ogden Publishing Company, 55 West 42nd Street, New York 36, N. Y. Subscription $4.00 a year, Canada and foreign, $5.00. Single copies 40 cents domestic, 60 cents Canada and foreign. Issues over three months old 60 cents; over one year $1.00. Entered as second class matter August 10, 1921, at the Post Office at New York, N. Y., under act of March 3, 1879.

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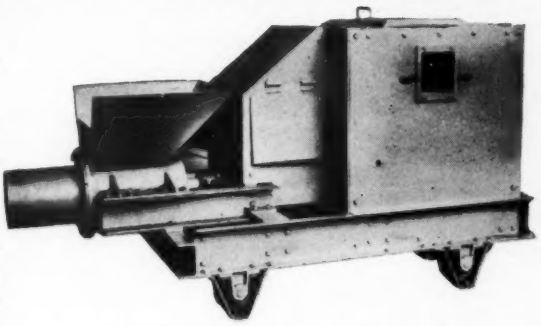

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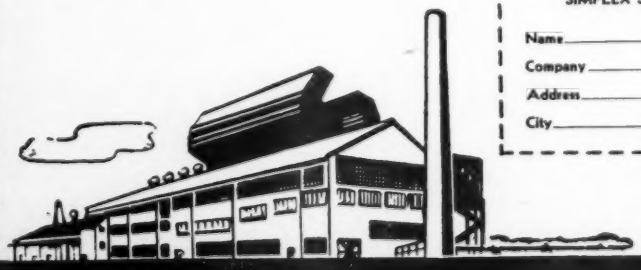

COMPLETE GLASS MANUFACTURING PLANTS
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THE GLASS INDUSTRY
VOLUME 35, NUMBER 12, DECEMBER, 1954

NETWORKS IN GLASSES AND OTHER POLYMERS

By J. M. STEVELS
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Editor's Note: This paper was delivered at the joint meeting of the Nordiska Glastekniska Foreningen and the International Commission on Glass at Vaxjo, Sweden, on June 18, 1954. With the consent of the Editor of *Glasteknisk Tidskrift*, we take pleasure in publishing this English version almost simultaneously with publication of the Swedish version in that journal.

Networks in glasses

According to the now classical conceptions of Zachariasen, the structure of fused silica consists of a rather open network of oxygen tetrahedra, in whose centers silicon atoms are found and which share only corners with each other. All oxygen atoms "belong" to two tetraehedra and they are therefore denoted in the literature as "bridging oxygen atoms".

The silicate glasses, which may be obtained by melting different quantities of metallic oxides with SiO_2, have similar structures. The metallic atoms (usually called the network-modifying atoms) have been shown to be taken up in the interstices of the network, whereas the excess of oxygen is taken up in such a way that each bridging oxygen atom is replaced by two oxygen atoms, which each "belong" to the tetrahedron, the "non-bridging oxygen atoms". Figure 1 shows the well-known representation of Zachariasen of the structure of a glass.

Obviously, the network as a whole becomes weaker and weaker, the more metallic oxide and thus "non-bridging oxygen atoms" are introduced and the more the degree of interlinkage of the network decreases.

In order to discuss these phenomena in a more quantitative way, certain numbers have been introduced, viz.

R = the ratio of the total number of oxygen atoms to the total number of silicon atoms.

X = the average number of non-bridging oxygen atoms per tetrahedron.

Y = the average number of bridging oxygen atoms per tetrahedron, or the average number of corners per tetrahedron shared with other tetrahedra.

Obviously $\left.\begin{aligned} X + Y &= 4 \\ X + \tfrac{1}{2}Y &= R \end{aligned}\right\}$ or $\left\{\begin{aligned} Y &= 8 - 2R \\ X &= 2R - 4 \end{aligned}\right.$

For a given chemical composition, R is known and X and Y can therefore be calculated straight away.

For instance, for fused silica (SiO_2), R = 2 and therefore Y = 4 and X = 0; in other words: all oxygen atoms are bridging, all tetrahedra share their four corners with other tetrahedra, and the network has therefore a very high degree of interlinkage.

For the glass of the composition $Na_2O.SiO_2$, R = 2.5 and therefore Y = 3 and X = 1, or in other words: all tetrahedra share on the average 3 corners with other tetrahedra, whereas there is in the mean 1 non-bridging per tetrahedron. This network has thus a lower degree of interlinkage.*

Obviously, the number Y, defined as the average number of corners per tetrahedron in common with other tetrahedra, is a direct measure for the degree of interlinkage of the network and, as a consequence, for the rigidity of that network.

This may easily be verified by playing around with the models of the networks, as shown in Figs. 2-5.** The values of Y for the networks given are 4, 3, 2.6 and 2.2 respectively. Whereas the first network is very stiff, the last excels in very great mobility and suppleness.

No need to say that these differences in the network are found in numerous physical and chemical properties.[1] Generally speaking, when passing from Y = 4 to lower values, the coefficient of expansion increases, the various reference points on the viscosity-temperature curve come down, the leachability increases, the chemical and electrical resistance decreases; in short, the different glasses can be said to become weaker and weaker.

Generally speaking, glasses for which 4 > Y > 3 are

* Naturally, the numbers X and Y are, as a rule, not integers: For instance, a value Y = 3.2 means that 20% of the tetrahedra have 4 corners in common with other tetrahedra and 80% of the tetrahedra have 3 corners in common with other tetrahedra, etc.

** The models shown in Figs. 2-5 are made from ordinary corcs and copper wire. The soldering points represent silicon atoms, the light corcs represent bridging oxygen atoms, the dark corcs non-bridging oxygen atoms. Though the models are rather primitive, photographs of them are published here since it is believed that they have great didactive value. The reader will understand that the network-modifying ions are not represented in the network.

technically useful (the best compromise between relative "easy meltability" and sufficient rigidity for technical purposes is found for $3.6 > Y > 3.2$). For $Y < 2$, a stable spatial structure of the network is no longer possible. For $Y = 2$, chains may be formed with infinite length. For decreasing values of Y, the length of the chains decrease too, the relation between Y and the average number of tetrahedra per chain q being

$$Y = 2 - \frac{2}{q} \quad (1).$$

The Power Factor of Glasses at Low Temperatures

Of special interest for the study of the properties of both spatial and linear networks is the knowledge of the power factor (dielectric losses) of these glasses for medium frequencies and at low temperatures.[2]

Though the electric power factor at room temperatures is mainly determined by the mobility of the network-modifiers, jumping through the interstices of the network, it has been shown in recent years that at low temperatures the network itself or, more precisely as is shown in this paper, certain negatively charged parts of the networks are responsible for a contribution to the dielectric losses.

In Fig. 6 the power factor of a glass A (composition in weight % 70.7 SiO_2, 0.5 Al_2O_3, 16.8 Na_2O, 1 K_2O, 5.5 CaO, 3.5 MgO, 2 BaO) is given as a function of the temperature for two different frequencies.[3] The form of these lines may be regarded as typical for all technical glasses. The form and especially the dependence on the temperature suggests that we have to do here with a typical relaxation phenomenon.

Fig. 7. shows the power factor of seven different samples as a function of the temperature for a frequency of $f = 10^3$ c/s.

A being the glass shown in Fig. 2 for which $Y = 3.2$.

B a technical borosilicate glass of the composition (in weight %) 57.5 SiO_2, 4 B_2O_3, 21.5 Al_2O_3, 0.4 K_2O, 6.3 CaO, 9.3 MgO and 1.0 BaO for which $Y = 3.88$.

C a technical lead-silicate glass of the composition, (in weight %) 58.5 SiO_2, 0.3 Al_2O_3, 6.5 Na_2O, 4.7 K_2O and 30.2 PbO for which $Y = 3.4$.

D a glass with the composition (in mole %) 12.5 Na_2O, 12.5 K_2O, 12.5 CaO, 12.5 BaO, 50 SiO_2, for which $Y = 2$.

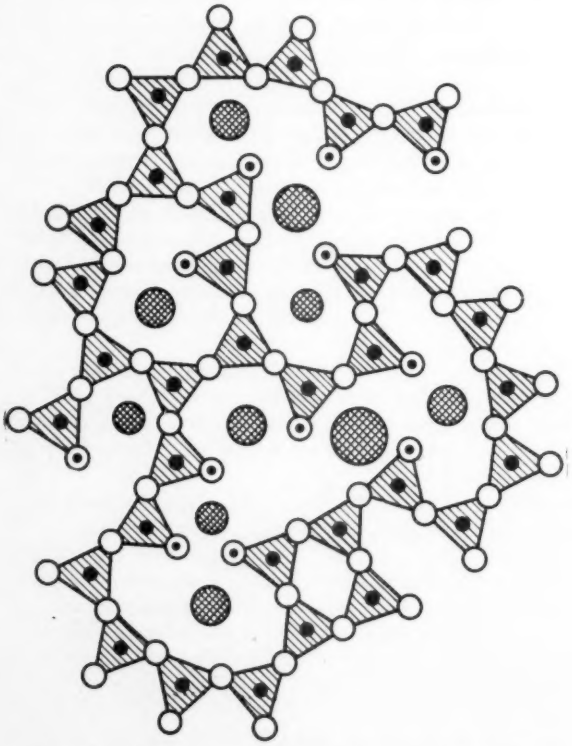


Fig. 1. The well-known schematic two-dimensional representations of a silicate glass according to Zachariasen. Silicon atoms are represented by black dots, the network modifiers by grey circles, bridging oxygen atoms by white circles and nonbridging oxygen atoms by white circles with dot.

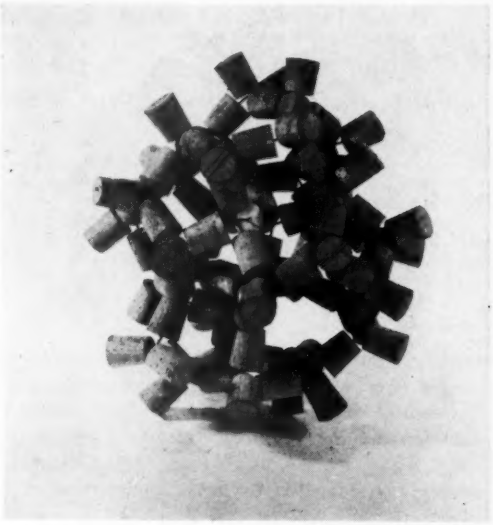


Fig. 2. A three-dimensional model of the network of fused silica ($Y = 4$).

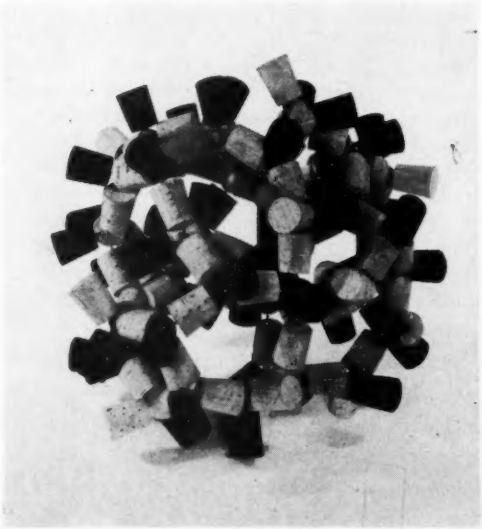


Fig. 3. A three-dimensional model of the network of a glass for which $Y = 3$.

E a quartz glass with a fairly considerable amount of contaminations.

F a very pure quartz glass, and finally

G a very nice especially chosen crystal of quartz without twin boundaries of irregularities. Obviously, the values for Y for the samples E, F, G are practically equal to 4.

All these samples show an increase of the power factor for rising temperatures, phenomenon which must be assigned to mobile network-modifiers, but this part of the curve does not interest us now. The parts of the curves which *do* interest us are the peaks at very low temperatures. Obviously, all glasses have these peaks in common. Apparently for glasses A-D inclusive, the cause of these losses is present in abundance, whereas for the cases E-G inclusive, only a very small, but still detectable peak is found. The very pronounced sharp peak in quartz crystal G suggests that we have to deal here with the phenomenon proper.

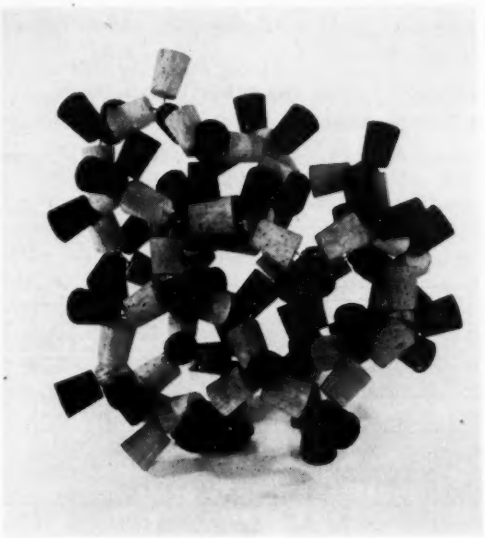


Fig. 4. A three-dimensional model of the network of a glass for which Y = 2.6.

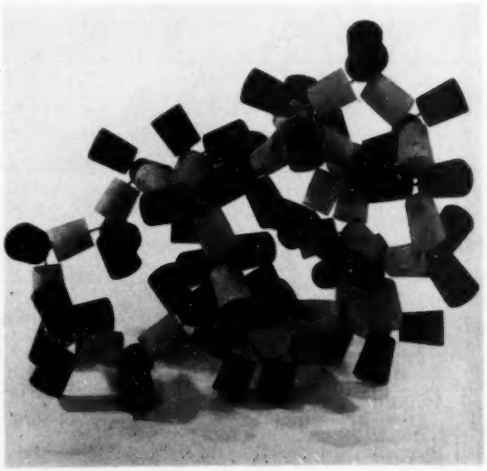


Fig. 5. A three-dimensional model of the network of a glass for which Y = 2.2.

An analysis of the peak in this quartz crystal as a function of the temperature for 2 different frequencies (Fig. 8) shows that its shape is really given by a Debye curve:

$$\tan \delta \sim \frac{\omega\tau}{1 + \omega^2\tau^2}$$

in which $\omega = 2\pi f$ (f = frequency applied) and τ is given by $\tau = \tau \sim \exp. Q/kT$. $(\tan \delta)_{max}$ is found for

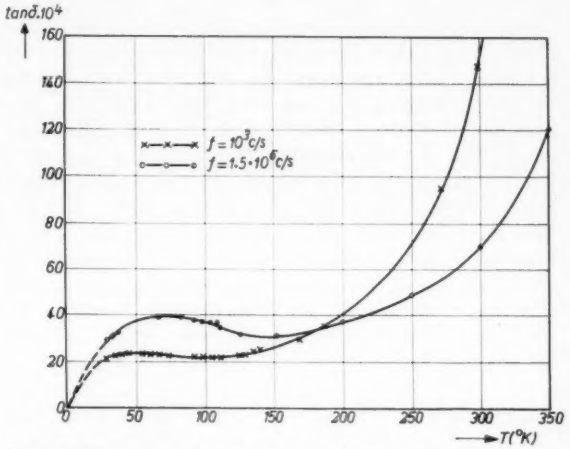


Fig. 6. The power factor of a soft lime glass as a function of the temperature measured for two different frequencies.

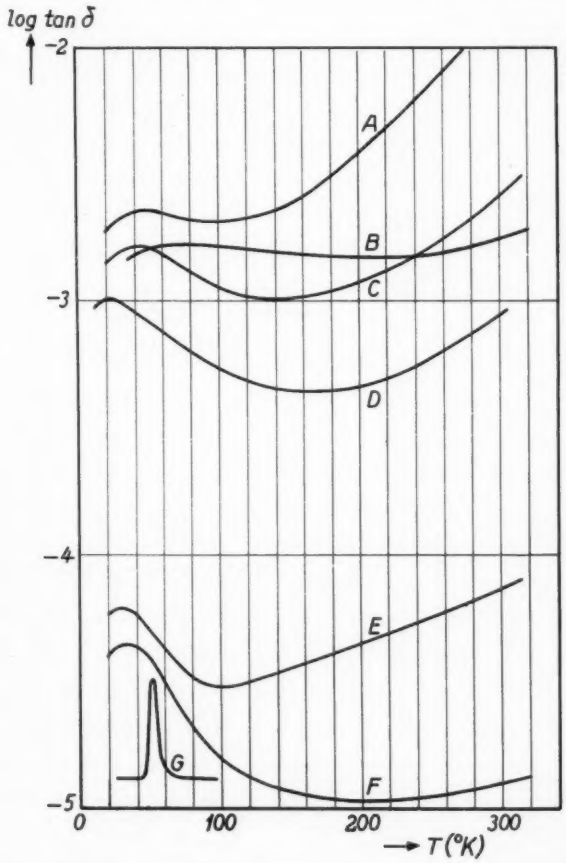


Fig. 7. The power factor of seven different samples A-G as specified in the text as a function of the temperature measured at a frequency of 10^3 c/s.

the temperature T_{max}, where $\tau = \frac{1}{\omega}$ for a pure relaxation phenomenon, the activation energy ϕ being 0.089 eV and the relaxation time $\tau \sim = 2.44 \times 10^{-13}$ sec.

It is rather easy for the other examples A-F to separate the relaxation due to the movements of the positive particles from the relaxation phenomena now discussed since the former may be represented by a straight line in a plot of log tan δ versus T. However, it is difficult to analyze the remaining relaxation losses—sometimes called deformation losses—in the cases A-F since these are the result of a wide range of relaxation processes. Taking the deformation losses proper and plotting $(\tan \delta)_{max}$ for samples A-F against X or Y, we obtain an interesting result (Fig. 9). Supposing a relaxation time $\tau \sim = 10^{-12}$ sec. (as a kind of average for all cases), the activation energy of the relaxation process can directly be calculated from the situation of T_{max} (provided we always measure with the same frequency for which we have chosen $f = 10^3$ c/s). In Fig. 9 the values of ϕ found in this way are also plotted against X and Y. It may be noted that the assumption of $\tau \sim = 10^{-12}$ sec. all over is rather arbitrary, but it may easily be seen that insertion of values $\tau \sim = 10^{-11}$ sec. and $\tau \sim = 10^{-13}$ sec. respectively do not considerably affect the value of the activation energies found.

Finally, Fig. 9 also shows $\Delta\epsilon$, the change in the dielectric constant of the glasses involved in passing from the right to the left of the tan δ-peak, as a function of X and Y. It is well-known from the general theory of relaxation losses that ϵ decreases as a function of decreasing temperature and/or increasing frequency in those regions where the relaxation losses occur. The extent of this decrease is directly proportional to the integral over all the Debye curves in case we have to do with a spectrum of relaxation times. From a theoretical point of view the expression $\Delta\epsilon$ is, therefore, a better quantity to discuss the extent of the phenomenon than $(\tan \delta)_{max}$. It is gratifying that both the $(\tan \delta)_{max}$-versus X and the $\Delta\epsilon$-versus-X-curves indicate practically the same trend. The provisional conclusion is now: in glasses, fused silica and quartz crystals, a relaxation mechanism exists, which is characterized by very short relaxation times ($\tau \sim = 10^{-12}$ sec.) and very low activation energies ϕ, ($\sim$ 0.04—0.1 eV.); in quartz crystal we may have luck and find the phenomenon proper, which can be described by one relaxation time; in glasses we usually have to deal with broad spectra of relaxation times. It is interesting to note that the maximum of $\Delta\epsilon$ and $(\tan \delta)_{max}$ coincides with the region $3.6 > Y > 3.2$, where the typical "glass properties" are optimal.

The Power Factor for Other Polymers at Low Temperatures

Figures 10, 11 and 12 show tan δ for a frequency

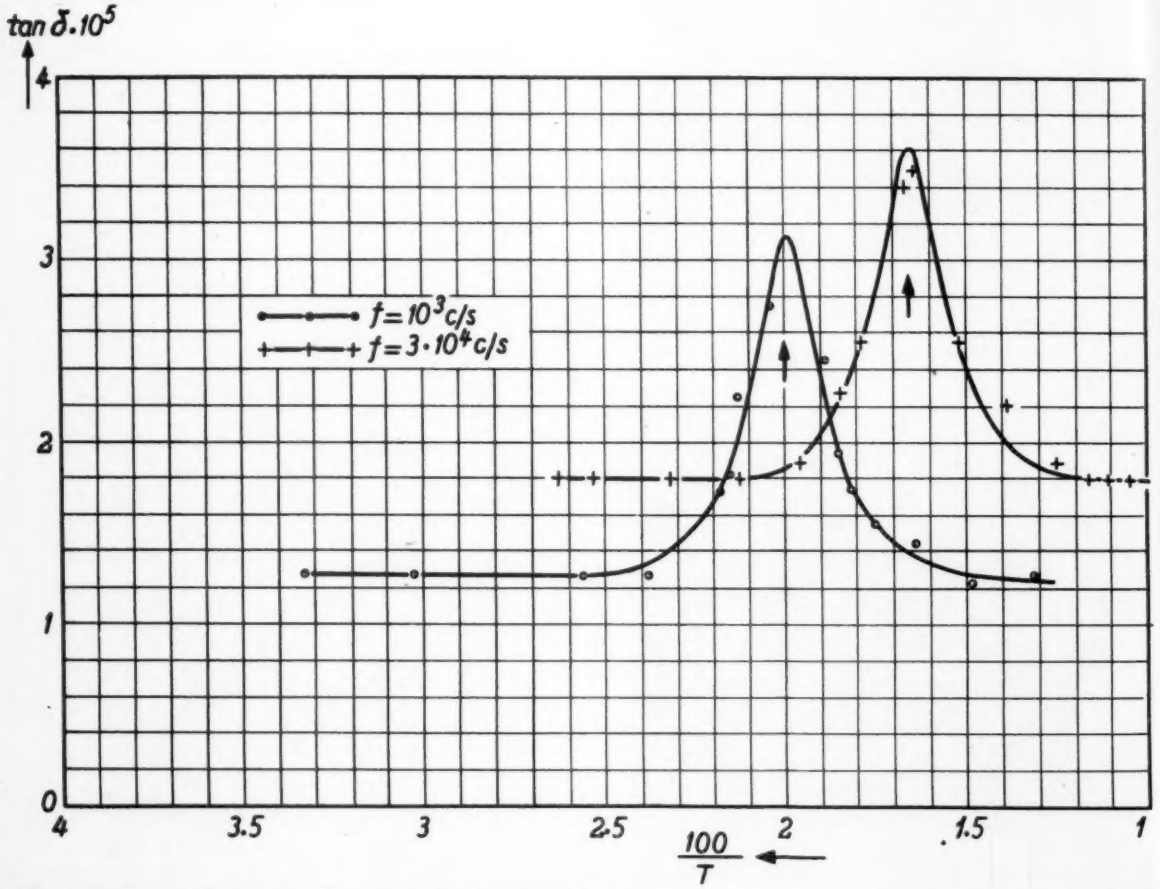
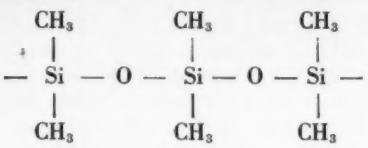


Fig. 8. The power factor of a practical ideal quartz crystal as a function of the temperature measured at two different frequencies.

$f = 10^3$ c/s as a function of the temperature for two dimethylsiloxanes



of different viscosities (DC 200, 100 and 500 centistokes resp.) and "silicone DC 701," which has probably a similar constitution except for the fact that a number of methyl groups have been replaced by heavier groups. The resemblance of the curves with those of the glasses, as far as the low temperature losses are concerned, is striking.

We have determined ψ, $\Delta\epsilon$ and $(\tan\delta)_{max}$ for DC 200 (100 c. st) in a similar way as for the glasses and inserted these quantities also in Fig. 9. It is very interesting to note that these values would fall on the curves already drawn for the glasses if the latter were extrapolated.

Discussion of the Relaxation Phenomenon Found

It is now time to make some careful speculations about the nature of the relaxation phenomenon described. We believe that it is caused by the movements of the non-bridging oxygen atoms, or rather the Si-O tails, formed by the non-bridging oxygen atoms in the external electric field applied. In the siloxanes it may be $Si-CH_3$ groups which have practically the same weight and have practically the same size and structure, though the latter no doubt have less polar character.

Of course, the phenomenon is highly influenced and modified (a) by the stiffness of the rest of the network to which the tails are coupled and (b) by the number and nature of the network-modifiers which the Si-O tails find in their neighborhood.

This paper will be concluded by discussing the trend of $\Delta\epsilon$, $(\tan\delta)_{max}$ respectively in these terms. Before doing so, it is interesting to state that synthetic forsterite, crystalline Mg_2SiO_4, shows no trace at all of low temperature losses and consequently no fall in the dielectric constant in this region. This crystal is built up of isolated SiO_4-tetrahedra (therefore plenty of Si-O tails), in between which abundant amounts of Mg^{2+} ions find their places in a regular pattern. No doubt the Si-O tails will not be able to move very easily in these circumstances—if at all.

We therefore get the following picture: Starting from $X = 0$ $(Y = 4)$, the Si-O tails can move only relatively difficulty (though it must be emphasized that a ϕ of 01. eV in itself is rather low indeed). In the quartz crystal and to a lesser extent in fused silica, the ever-present contaminations give rise to only a very few non-bridging oxygen ions. Passing to higher values of X (and consequently lower values of Y), the Si-O groups are bonded to more and more fluffy networks so that it will be more and more easy for them to move and to follow the external electric field.

However, there is an influence counteracting the phenomenon. The higher the X and the lower the Y, the more network-modifiers are introduced into the interstices and, therefore, the movement of the Si-O tails is hemmed (either by sterical hindrance or by chemical binding forces or both). The extreme is the example of the forsterite, where the great amount of Mg^{++} ions bind the Si-O tails so tightly to their equilibrium position that a response to the external field is practically impossible: very high values of ϕ will be involved. Generally speaking, therefore, it must be expected that both $\Delta\epsilon$ and $(\tan\delta)_{max}$ go through a maximum, whereas ϕ passes a

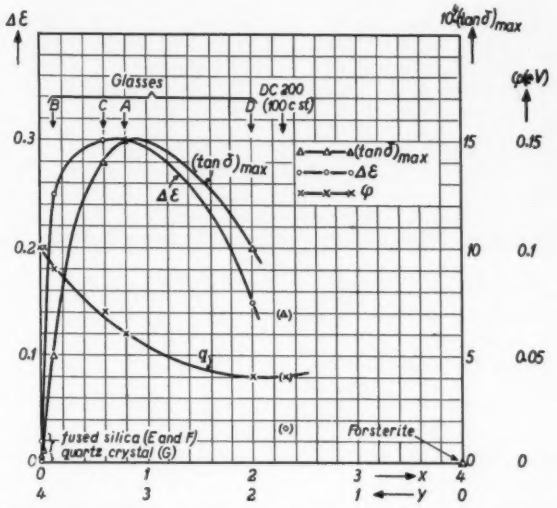


Fig. 9. Showing $(\tan\delta)_{max}$, $\Delta\epsilon$ and φ as function of X (resp. Y) for the seven samples A-G, silicones and forsterite.

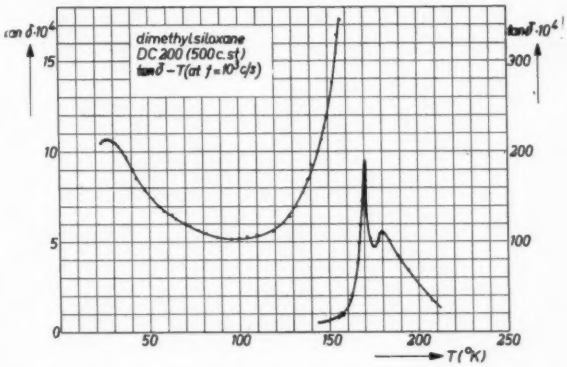


Fig. 10. The power factor of dimethylsiloxane DC 200 (100 c. st) as a function of the temperature measured at a frequency of 10^3 c/s.

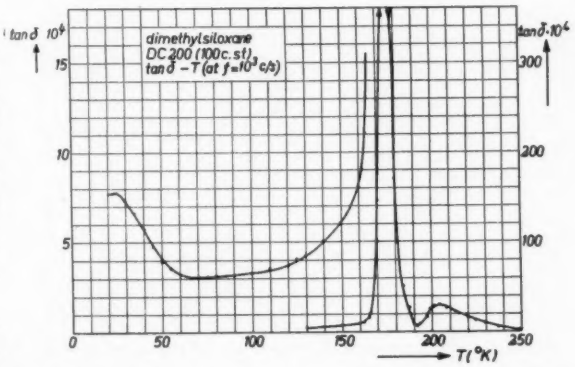


Fig. 11. The power factor of dimethylsiloxane DC 200 (500 c. st) as a function of the temperature measured at a frequency of 10^3 c/s.

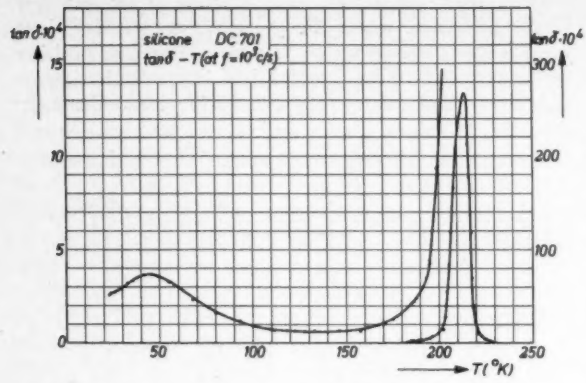


Fig. 12. The power factor of silicone DC 701 as a function of the temperature measured at a frequency of 10^3 c/s.

minimum as a function of X and Y, in accordance with Fig. 9.

Some Final Remarks

To conclude, four remarks must be made.

(1) It is surprising that the case of dimethylsiloxanes is situated in the curve in Fig. 9, (a) because the Si-O and Si-Ch_3 groups are different, both in dipole moment and in weight, (b) because there are no cations to counteract the movements of the Si-Ch_3 groups in silicones. On the other hand it is known that in this case there is always a certain degree of Van der Waal's interaction between the chains which make them less free than corresponding to the calculated Y values.

(2) The case of glass D is interesting from the point of view of the glass technologist. It is known that the composition $Na_2O.SiO_2$ (Y = 2) or $CaO.SiO_2$ (Y = 2) are just on the border line of being capable of forming glass. For higher values of Y, chains with limited length occur which have the tendency to give rise to crystallization[4]. However, choosing a batch with a great number of different network-modifiers (Cf. the case of glass D where Na^+, K^+, Ca^{++} and Ba^{++} is used), the "glue" between the chains is so irregular that crystallization is prevented.

(3) It is interesting to consider once more Figs. 10, 11 and 12, and especially the very large peaks on the right hand. These are perhaps due to the relaxation of the free ends of the polymers involved. In Figs. 10 and 11 we have siloxanes with different chain lengths. Both have a very sharp peak at about the *same* temperature, viz. 175° and 171° K resp. This means the fringe is the same in both cases, the activation energy of their movement probably being of the order of 0.3 eV, but since there are more free ends in the shorter siloxane (Fig. 10), the peak height is considerably higher. The siloxane with the heavier groups (Fig. 12) has a fringe which moves more difficulty. It is worthwhile to mention that the free ends of the siloxanes, as well as the DC 701, are usually marked with oxygen containing groups. These polar groups are probably the reason why these free ends move so violently on the action of the external field.

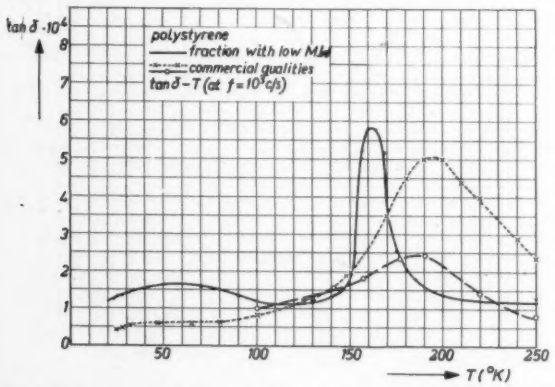
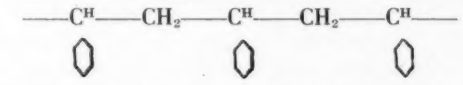


Fig. 13. The power factor of polystyrene as a function of the temperature measured at a frequency of 10^3 c/s.

Another possible explanation of the high peaks is that these are caused by a co-operate phenomenon (first grade phase transition). It is interesting to note that the peak temperature of tan δ for DC 701 (213° K) coincides with its melting point (208° K). In the case of the dimethyl-siloxanes (100 and 500 c.s.t. resp.) the melting points of 218° and 223° K resp. do not coincide with the peak temperatures of tan δ (175° and 170° K resp.).

(4) Finally, Fig. 13 shows a number of curves for different samples of polystryene which have a tan δ-versus T curve of the same shape. From the chemical structure



it follows that the low temperature losses will be low anyhow, but the measurements show their existence beyond doubt. It is plausible to suppose that these losses are due to practically unpopular groups, viz. the C— ⬡ groups. The losses caused by the fringe are also very marked, especially for the case where a fraction with a lower average molecular weight has been investigated.

Related work has recently been published by Dietzel and Deeg[5] in the *Glastechnische Berichte*, and by Fine, van Duyne and Kenney[6] in the *Journal of Applied Physics* (both on low temperature mechanical losses) and by M. and R. Freymann[7]) in the *Journal de Physique et le Radium* (low temperature dielectric losses in crystals).

LITERATURE

(1) Cf. J. M. Stevels, Verres et Refractaries, 7, 91 (1953); The Glass Industry *35*, 69, 135 (1954)
(2) Cf. J. M. Stevels, Glast. Berichte *26*, 227 (1953)
(3) Published earlier in Glast. Ber. *26*, 227 (1953)
(4) Cf. H. Moore and M. Carey, J. Soc. Glass Technol. 35, 43 (1951)
(5) A. Dietzel and E. Deeg, Glast. Ber. *27*, 105 (1954)
(6) M. E. Fine, H. van Duyne and N. Kenney, J. Appl. Physics *25*, 402 (1954)
(7) M. Freymann and R. Freymann, Journ. de Physique et el Radium *15*, 217 (1954)

REFRACTORIES INSTITUTE ISSUES DIRECTORY

The Refractories Institute has announced the publication of a Product Directory of the refractories industry in the United States.

This volume lists over 2,000 brand names produced by 159 refractory manufacturers. The Directory is cross-indexed for ready reference by companies, plant locations, product divisions and brand names.

Copies of the Directory may be secured at $2.00 each from The Refractories Institute, First National Bank Building, Pittsburgh, Pa.

G.C.M.I. MEETS IN COLORADO SPRINGS

Walter Williams, Under Secretary, U. S. Department of Commerce, and Bert Cremers, Wyandotte Chemicals Corporation, pause to chat during G.C.M.I. activities.

For the first time since its organization, the Glass Container Manufacturers Institute held its membership meeting west of Chicago, October 24 through 27. The place: The Broadmoor, Colorado Springs, Colorado. The meeting was well-attended, with an excellent showing from California.

President J. M. Nester stated in his opening remarks that the Institute's membership remains the same as it was at the time of the May Annual Meeting. The Institute is comprised of 43 glass container manufacturers, 15 closure companies and 20 supply and allied manufacturers.

In commenting on the condition of the glass container industry, Mr. Nester said that over-all volume for the past eight months has been maintained unusually well, especially so in view of last year's all-time peak volume. He pointed out competition from other container materials and discussed remedial activity to meet this competition.

With regard to labor relations, it was pointed out that labor, of course, is the largest single cost factor and that this necessarily has a direct bearing on the industry's ability to meet competition.

Referring to the work of the Package Design and Specifications Committee, Mr. Nester stated, "The second largest cost factor is packaging, including shipping carton and supplemental packing materials. The program of this Committee and the Packaging Laboratory at Butler is designed to develop packaging which gives greater product protection per dollar of packaging cost, to protect the industry against unnecessary increases in these costs and through research and development work to reduce costs through the elimination of over-packaging. During the seven years the Laboratory has been functioning, we have been confronted with many problems which, had they not been solved, would have given the industry a "black eye" or would have further increased our packaging costs."

Testing procedures work at the Preston Laboratories in Butler has been going along at a steady pace and it is expected that with the addition of one more member to the staff, Dr. Richard Mould, this group's contribution to the progress of glass will be greatly enhanced since some additional basic research is planned on "glass as a substance".

Mr. Nester, in outlining this subject, stated, "My purpose in setting forth the above detail was two-fold: (1) to show that your technical representatives on Package Design and Specifications and Testing Procedures Committee believe in and are carrying on some technical research with their limited facilities; and (2) to point up the fact that a program of basic research would in time greatly facilitate the applied work of these two committees and would generally promote the purposes for which the Institute was formed."

Reports of the various Committees of the Institute were submitted to the membership, including a report from Smith Rairdon, Owens-Illinois Glass Company, who has spear-headed the planning and organization of Keep America Beautiful, Inc., now a going enterprise in the fight against litter on the nation's highways and public parks.

During the three-day meeting, the Institute's membership was treated to a dynamic address by Walter Williams, Under Secretary of Commerce, U. S. Department of Commerce. In his talk, Mr. Williams vividly dramatized the tremendous buying power of the American public and its equally tremendous growing potential.

(*Continued on page* 690)

Lunching together during the Ladies' Luncheon are Mrs. F. W. McDonald (Glass Containers, Inc.), Mrs. C. F. Bingham (Columbia-Southern Chemical Corp.) and Mrs. A. S. Reese (Tygart Valley Glass Company), who served as a Committee in charge of this affair.

VARIED GLASS PROGRAM PRESENTED AT 7th PACIFIC COAST MEETING

Los Angeles provided excellent weather for the opening of the 7th Pacific Coast Regional meeting of the American Ceramic Society, which was held October 27, 28 and 29 at the Ambassador Hotel. Registration exceeded 700, which was an all-time high for a West Coast meeting.

The morning of the opening day featured discussions on ceramic education by Dr. Joseph A. Pask of the University of California and Dr. James I. Mueller of University of Washington who appealed to industry to interest men in taking undergraduate work in ceramic engineering. At present, ceramic enginering students comprise slightly less than 0.3% of the total engineering undergraduates and of this small percentage, a large number go directly into technical sales.

The afternoon session was devoted to a discussion of managerial problems by authorities from other industries. The subject matter was diversified to include the relation of ceramic products to industrial design, the architects view of ceramic products, the principles of marketing and industry attitudes. During this series of talks, the speakers stressed the importance of coupling product values with popular appeal.

"Problems of Growth of Western Industry" was the subject of an address by Weldon B. Gibson, Director of Economic Research, Stanford Research Institute. Dr. Gibson stated that during the past 30 years the population increase in the United States was less than 1% per year, whereas in the West it was 2.6% per year. Studies indicate that twenty years from now, in 1975, there will be an increase in population in the West from the present 21 million to 37 million, and that about 22 million people will be living in California. There will consequently be an increase of economic activity in California of 100 to 125% above 1954 levels. Because of the permanency of silica and clay products and because of the rapid demand for high temperature resistant materials, the growth of the ceramic industry should follow and possibly exceed industry expansion.

E. E. Humphrey, Corhart Refractories Company, discussed "Tank Insulation", a subject of interest to all glass tank designers and operators because of the possibilities of lowering fuel costs and extending furnace life, which means a greater tonnage of glass for the life of the tank.

Application of insulation to installations that use electric melting was discussed, and particular stress was put on the possibility of insulating melting end sidewalls and bottoms, which up to now is not common practice. However, many manufacturers are now paving bottoms with fused cast material with very good results, resultant long bottom life and a reported savings in fuel. Although experience with sidewall block insulation is not as conclusive, there is much evidence that partial insulation, up to 4" to 6" of the top, decreased wear on the block.

Mr. Humphrey outlined the use of refractories in ports #1 and #2, and insulation of these refractories. Crown and regenerator insulation was referred to for the purpose of prompting discussion from the floor.

In concluding, Mr. Humphrey submitted the following five points: (1) With regard to crown insulation, there appears to be more failures than successes; (2) Tank size is an important factor; (3) Fuel savings can be as much as 3%; (4) Working conditions are certainly better; (5) Some stone problems have been bettered by insulating certain specific areas.

Remarks from the floor by operators and suppliers brought out many conclusions. Discussion was constructive and lively as practical operators and suppliers of various types of refractories entered into a frank appraisal of the situation. The outstanding conclusion was that the most important factor is the importance of individual operation without which tanks can be easily ruined regardless of the type of refractories and insulations.

V. H. Remington, B. F. Drakenfeld & Co., Inc., presented a paper entitled "Automatic Machines and Thermoplastic Printing Colors". New and modern media which made possible improvements in design and operation of automatic screen printing machines were reviewed. Operational difficulties, such as "running", "scalloping", "blistering", "pin-holding" and "pick-up", were briefly discussed in respect to both the established and the new hot printing color processes. This latter process is accomplished through hot thermoplastic printing mediums. As a result, it is now possible to further improve efficiency, design and automatic operation, and in this way get the benefit of lower production costs.

In developing the advantages of hot thermoplastic printing media for machines, it was found that the printed design was clearer, and that there were fewer "misprints". Mr. Remington discussed cost factors, improvements in formulation and such modern equipment as the Solar type and the Hagerman attachment. As a result of automation, bottles can be decorated faster and better.

Anthony Tazzolino, of the Overton Foundry, discussed the subject, "American Glass Mold Iron vs. European and Italian Glass Mold Iron". This practical review included the use of wooden samples and mold patterns. Methods of chill were referred to, and the importance of iron compositions and additives to cut down oxidation was stressed. Emphasis was placed on such factors as metal density and homogenity, as well as on typical defects as pin-holes, porosity and hard spots. In concluding, the speaker called attention to the need for close control of all operations. More papers of this type will be welcomed by mold designers.

V. C. Swicker, Consultant in Glass Technology, discussed "West Coast Glass Sands". Very interesting situations are developing in the sands supplied to the glass centers on the Pacific Coast. The Los Angeles area receives sand from four distinct areas: Corona, Monterey Peninsula, Oceanside and Overton Nevada. There is no indication of significant changes in the supply of sand for this area. However, the Oceanside sand is to be benficiated so as to reach an expanded market.

In the San Francisco area, sand comes from three different areas: Ione, Monterey Peninsula and Overton Nevada. The Ione operations are being expanded, "plymouth" sand is to be placed on the market, and there are rumors of a newly-formed company at Brentwood. A changing situation can be expected during the next year.

The glass factory in the Seattle area receives amber sand locally, but flint glass sand comes from such distant points as Illinois, Overton Nevada and Belgium. The shortest freight haul is consequently about 1300 miles.

Reference was made to the types of sand: high silica, medium high alumina (3.5 - 6.0%) and high alumina (over 6%), and to the influence of these sands on the composition of the glasses. Along the West Coast, glass compositions range from about 2% alumina to over 9% alumina. Proportioning a batch under these conditions to get desirable meltings and working characteristics is an undertaking that has no parallel in the container field in any other part of the country.

"The Determination of Calcium in Glass by Flame Photometry" was the subject of a paper by David Billings of Glass Containers, Inc., who stated that the need for more rapid methods of glass analysis becomes more important as the industry goes to higher speed production and lighter weight ware.

Flame photometry is one of the recent developments in the chemical analysis field that is being used by many laboratories for rapid chemical analysis. The determination of calcium by flame photometry is complicated by the effect of several constituents of glass on the calcium emission; also the reagents used in the preparation of glass for chemical analysis have a marked effect on the calcium flame. The elimination of the various interferences in the calcium determination has led to two successful techniques for flame determination of calcium. Recent improvements in flame photometers has also played an important part in the successful determination of calcium.

Glass tank life is always of interest to both technical and operation men. E. K. Pryor, Pryor-Giggey Company, discussed special refractories and concluded that "Physical Properties are the Key to Performance". "Developments in Zircon Refractories for the Glass Industry", discussed by R. W. Knauft, of Chas. Taylor Sons Company, was of much interest to the entire group. The relation of density of the finished zircon refractory to the resistance of the refractory to erosion and corrosion was illustrated by a series of slides. A progress report was given covering the use of dry pressed zircon brick and high-density fine-grained bonded zircon tile as paving over clay tank blocks in the bottoms of continuous glass tank furnaces. Bonded zircon brick and/or high-density tile are being used successfully for bottom paving in continuous furnaces melting borosilicate, dense opal and soda-lime flint glasses. A number of slides were shown to illustrate the effectiveness of using bonded zircon brick and shapes in furnace construction above the glass line. Zircon is not readily attacked by silica slags or wash. They are more readily attacked by basic slags or those which are high in alumina. Zircon brick was recommended as a "drip course" in the furnace crown to prevent silica wash from flowing over aluminum-silicate or fused cast refractories used as port jambs, breast walls, tuckstones, etc.

A rapid and economical method of identifying compounds formed at the interface between various glass tank refractories and glass was described. An ultraviolet lamp of the cold quartz type of "black light" concentrated at wavelength of 2,537 Angstrom units is used. The effect of the ultraviolet is almost instantaneous on exposure and phenomena pertaining to the fluorescence and phosphorescence of the commonly used glass furnace refractories were presented. The method is not effective if the refractory is imbedded in or is coated with the glass.

Interest in the performance of all types of refractories in glass tanks was evidenced by the discussions following Messrs. Humphrey's and Knauft's papers.

The concluding general session was devoted to automation, with J. W. Mahoney, of Gladding McBean, acting as Chairman of a panel of four speakers.

W. D. Smiley, of Stanford Research Institute, in discussing the economic necessity for automation in the ceramic industry, pointed out that in 1954 annual sales for the entire ceramic industry were 6½ billion dollars, of which about 15% were clay products. Clay products sales have been on a downward trend since 1951, and are facing serious foreign competition. Mr. Smiley quoted a comparison between the cost of producing clay products as compared to glass containers in 1952.

	Glass Containers	Clay Products
Labor	30%	48%
Material	45	28
Other costs	25	27

Obviously, the factory output per man hour must be increased, and much of this can be accomplished by automation, taking advantage of the fact that "Horsepower is cheaper than manpower".

The fourth speaker, Chat Dillon of the Latchford-Marble Glass Company, reviewed the progress of automation within the glass industry and indicated that the ceramic industry in general could benefit from developments within the glass industry.

J. W. Mahoney's additive comments on the over-all ceramic field left not a shadow of a doubt in the minds of the audience that to survive, the American ceramic industry must first of all recognize that the customer is the boss, and that we are facing a new type of competition, including that of the "muscular giants" of other industries who are aggressive and progressive. Actually it is "later than we think", and unless the ceramic industry presents a united front and recognizes that knowledge is power, some of our present companies will not be in business five years from now.

COLUMBIA-SOUTHERN APPOINTMENT

H. C. Twiehaus has been named Manager of the Planning Department for the Columbia-Southern Chemical Corporation.

Prior to his appointment, Mr. Twiehaus was Director of Development for the firm's Natrium, West Virginia, plant. He joined Columbia-Southern in 1940, following his graduation from Kansas University, and will make his headquarters at the firm's general office in Pittsburgh.

• Carl R. Megowen, President of Owens-Illinois Glass Company, has been re-elected a Board member of the National Industrial Conference Board, an independent nonprofit institution for business and industrial fact finding through scientific research.

STRAINS AND THE TRANSFORMATION REGION OF GLASS

By FRANCIS NAUDIN Eng. D.

TRANSLATED FROM VERRES ET REFRACTAIRES, SEPTEMBER-OCTOBER 1952

By KATE GAY EELLS* and NEILL M. BRANDT**

Part IV

Abstract

In this concluding part of the series, Naudin treats the static method of investigation of birefringence and of refractive index. The variation of birefringence and of refractive index with time at constant temperature for a number of temperatures in the elastic and the transformation range was studied. The two properties were measured nearly simultaneously at the actual elevated temperature by the equipment previously described. None of the constant temperature experiments was continued beyond two weeks.

Naudin noted a great similarity between the curves of birefringence and refractive index with time and concluded that both properties are the manifestations of the structural state of the glasses. He found that with quenched glass these two properties undergo appreciable changes at temperatures slightly below the lower limit of the transformation region. With well-annealed glass there were no observable shifts in the properties. The rate of cooling had no influence on the properties provided cooling commenced in the elastic range.

Experiments in the transformation range were limited to temperatures where deformation of the specimen prism would not occur. With deeper penetration into the transformation, the time required to attain equilibrium decreased, and the equilibrium values of both birefringence and refractive index were lower, the value of birefringence decreasing to zero near the upper limit of the transformation range. The usual effects of structure produced by previous thermal history were also noted. The equilibrium value characteristic of a given temperature may be approached from values either above or below that value. The rate of approach to the equilibrium was some unknown function of time and temperature. Naudin recognized that this function is complex and that most investigators have been tempted by oversimplification.

The effect of cooling from a temperature within the transformation region after equilibrium index and birefringence were attained was dependent upon rate of cooling and upon transformation rate in the immediate temperatures traversed. Near the lower limit of the transformation range, the rate of retreat from the temperature could easily exceed the rate of transformation and the elastic range could be reached without appreciable shift in index or birefringence. In the upper areas of the range such rate relationships were reversed and reaching the elastic range with unchanged properties was unavoidable. N.M.B.

Static Study at Constant Temperature of Refractive Index and Birefringence as a Function of the Time

In this fourth part, we explain the behavior at constant temperature of the glasses previously studied at variable temperature.

In the same way, we divide into two parts the study of birefringence and refractive index as a function of time at constant temperature. The temperature chosen lies either in the interval between room temperature and the lower limit of the transformation range, the elastic range, or in the transformation range.

I. The Elastic Range

Since we were able to set up only a single apparatus for simultaneous measurement of birefringence and refractive index, we never extended any test beyond about two weeks. The experiments carried out at temperatures where the glass behaves as an elastic solid started at about 150°C. Although at these temperatures months and perhaps years are required in order to perceive appreciable change in the physical constants of glass, experiments of relatively short duration often make it possible to forecast the behavior of the glass with time at this temperature.

For this temperature range, the experiments were made on a borosilicate-crown and a dense flint glass. The borosilicate-crown was kept at 125°C. for 125 hours, at 250°C. for 30 hours, and 350°C. for 25 hours, at 400°C. for 200 hours and at 450°C. for 75 hours. The dense flint was held at 100°C. for 90 hours, at 200°C. and 300°C. for 75 hours, at 350°C. for 60 hours and at 375°C. for 30 hours.

The experiments on these two glasses showed certain similarities which make it possible to draw general conclusions concerning glass kept at a constant temperature below the lower limit of the transformation range. In the first place, there was a similarity between the birefringence curve and the refractive index curve as a function of the time. This similarity proves that, at these temperatures, the shifts of these two physical constants (refractive index and birefringence) are the manifestation of the structural state of the glass determined by the temperature and the degree of annealing.

It has long since been shown that the refractive index of a sample of glass, held at constant temperature for sufficient time for it to come to equilibrium, was a function only of the temperature and the structure that it could acquire at this temperature. Thus, this similarity between the strain curve and the refractive index curve as a function of the time connects the birefringence of the sample with the structure of the glass at this temperature and also with

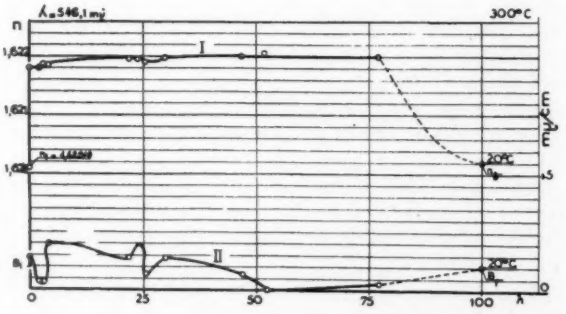


Fig. 12. Variation of refractive index as a function of the time at 300°C. (curve I for $\lambda = 546.1$ mμ) and birefringence (curve II) of a dense flint. *Ordinates* (left): index; (right): birefringence mμ/cm. *Abscissas:* time in hours. n_i, n_f: initial and final indexes at 20°C. B_i, B_f: initial and final birefringences at 20°C.

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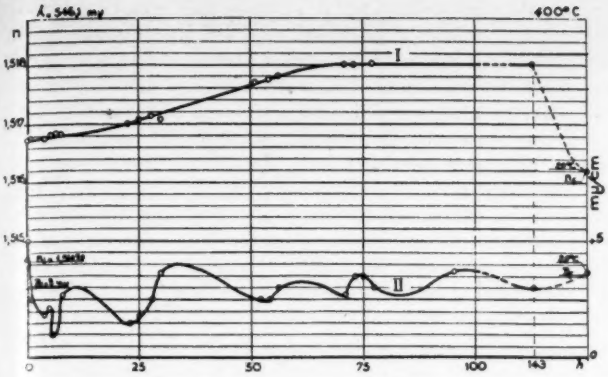

Fig. 13. Same legend as Fig. 12: borosilicate-crown at 400°C.

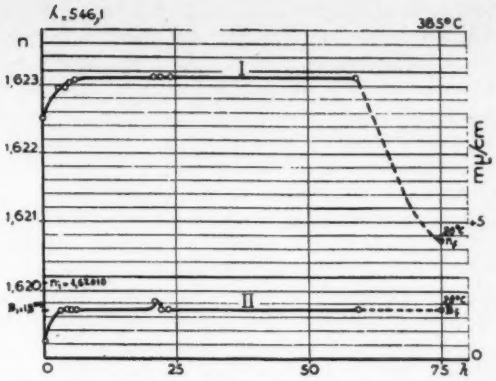

Fig. 14. Same legend as Fig. 12: dense flint at 385°C.

the thermal gradient which might prevail in the piece of glass.

The experiment made with the dense flint at 300°C. perfectly illustrates this view. It is represented in Fig. 12. The refractive index of 1.62200 reached its stable value at 300°C. almost immediately (within a few hours); it retained approximately this value of 1.62200 during the 75 hours of the experiment.

The birefringence underwent abrupt shifts during the first hours, while the index increased its equilibrium value. During the remainder of the 75 hours the birefrigence decreased very slowly from 1 mμ/cm to 0.5 mμ/cm. Thus the value 1.62200 for the refractive index and 0.5 mμ/cm for the birefringence characterized the stable condition of this glass at 300°C.

After slow cooling from 300°C., the refractive index underwent a slight increase (10^{-4}) with respect to its initial value at 20°C. (1.62010). This was equal to the increase acquired by the index during the first hours at 300°C. The final birefringence B_f (1 mμ/cm) was the same at that before the experiment (B_i), of the same order as the average value at elevated temperature. The glass was originally fairly well-annealed and a heating to this temperature did not modify the structual state to any practical degree.

An interesting fact must be noted. About the 25th hour, probably in consequence of a mild heating incident (draft or drop in voltage), the refractive index value momentarily dropped abruptly from 1.62195 to 1.62190 and then resumed its original value of 1.62195. The phenomenon lasted approximately 6 hours. Concurrent with the index fluctuation, the strain underwent substantial shifts. The duration of this disturbance as indicated by the strain was also 6 hours. Thus, once more the simultaneousness of variation in birefringence and refractive index and their similarity of variation are confirmed.

When this experiment was performed with badly annealed or tempered glasses, an annealing started at temperatures below the lower limit of the transformation range. It was manifested by an increase in refractive index and generally by a decrease in birefringence. After cooling, the increase in refractive index was retained and the birefringence became stable at a value closer to zero than its initial value. The borosilicate-crown kept at 400°C. illustrates this case perfectly (Fig. 13).

During the first 70 hours of the test at 400°C., the refractive index increased linearly as a function of the time from 1.51670 to 1.51800, remaining unchanged during the following 75 hours. The 5 mμ/cm birefringence at the beginning of the test decreased to 1.8 mμ/cm in the first 4 hours; from this time it increased from 3.5 mμ/cm at 100 hours at 400°C. The oscillations of the curve around the mean value, which increased linearly with the time, cannot be laid to errors in measurements. They are not evidence of slight oscillations of temperature, which would be made evident simultaneously on the index curve, but rather indicate the formation of new intermolecular bonds during the thermal treatment.

All this is valid for a badly annealed or quenched sample. On the contrary, heating an annealed sample such as dense flint at 300°C. (Fig. 12) to a temperature below the lower limit of the transformation range did not modify the refractive index and birefringence which it originally possessed at room temperature. It is in this sense that we speak of temperature range where the glass behaves as an elastic solid. For a well-annealed glass the cooling rate had no effect on the final state, provided the cooling began at a temperature in the elastic range and the sample was not fractured by excessive temporary strain which appears during too rapid cooling.

The chaotic appearance of the birefringence curve in Fig. 12 and Fig. 13 is explained by index shifts in the 7th decimal place for the ordinary and extraordinary rays, while the average refractive index curve shows shifts of total index which could not be measured to better than a few units of the 5th decimal place. These strain oscillations in the course of time do not correspond to the slight temperature shifts which would be evident on the index curve. Gradually the amplitude of oscillations diminished and after about fifty hours the curve acquired a steady trend. This phenomenon could be caused by the formation of new intermolecular relations which would increase viscosity in the course of the long thermal treatment at low temperature. Therefore, the relaxation of the strain cannot progress beyond some limit, at least for the durations involved in these tests.

II. The Transformation Range

The importance of structural gradient and structual equilibrium in the sample for the formation of permanent strain is brought out by heating at constant temperature in the transformation range. As the temperature of the glass

penetrates deeper into the transformation range, the equilibrium values of refractive index and of birefringence are obtained more rapidly. At temperatures near the lower limit of the transformation range, the glass reaches its structural equilibrium only after times of the order of weeks. Near the upper limit of the transformation range, a few minutes suffice for the sample to acquire a stable structure.

The transformation range cannot be explored in its entirety by the experimental method we used. Beyond a certain temperature, the glass becomes too fluid and the surfaces of the sample deform making refractive index measurement impossible. The measurement of birefringence also becomes difficult and inexact because of deformation of the plane faces of the thick plate formed by the truncation and the base of the prism.

If a well-annealed sample is kept at a temperature in the transformation range, the refractive index decreases to an equilibrium value. On the contrary, if a quenched sample is held at the same temperature, the refractive index increases toward the same equilibrium value. Thus, if the sample was originally in a structual state corresponding to a temperature lower than that to which it is held in the transformation region, its refractive index will diminish until it reaches the stable limit value corresponding to this temperature. The refractive index will increase till equilibrium is attained at this temperature in the transformation range if the sample was originally in a structure characterized by a temperature higher than that at which the sample is kept. Hence, for each type of glass, there corresponds to each temperature in the transformation range an equilibrium index which characterizes the structual state at that temperature.

The rate at which the refractive index tends towards it equilibrium value is a function of the temperature. This function does not seem the same when the fixed temperature is approached by heating or by cooling. It is difficult to put these laws into equation form. A simple exponential law, such as that describing radioactive decay, applies fairly well after the sample has been kept at fixed temperature for some time.

E. P. Condon[1], using data obtained by B. Daragan[2], showed that the variation in density with time at constant temperature can be represented by a series of exponential terms whose time constants differ. The same analysis holds for the relaxation of strain. It is studied as a decay in birefringence. Condon suggests that each exponential term represents a structural state which is destroyed as a new state represented by the following exponential term in the series is produced. Coexistence of these successive structural states explains the complexity of the equilibrium curves of the various physical constants (refractive index, birefringence, density) as a function of time at constant temperature.

The evolution of birefringence at constant temperature in the transformation range shows a few analogies with that of the refractive index. One may assert with Lebedeff[3] that at every temperature the birefringence varies and tends towards an equilibrium value. This limit value is zero for high temperatures when the viscosity is so low as to permit complete relaxation. At lower temperatures, the limit value is determined by the annealing temperature and by the initial birefringence.

The two experiments made with dense flint, at 385°C. and at 400°C., particularly illustrate this view (Fig. 14 and Fig. 15). The sample, originally at 20°C., was in a structural state close to that which corresponds to stability at high temperature. At 385°C., in 6 hours the refractive index increased from 1.62250 to 1.62310 and then remained constant during the remaining 60 hours of the test. The initial birefringence B_i at 20°C. was 1.8 mμ. At the beginning of the treatment at 385°C., it had decreased to 0.8 mμ/cm; it increased to 1.9 mμ/cm in 3 hours and remained constant during the rest of the treatment.

During treatment at 400°C., the refractive index of well-annealed DF decreased exponentially 90 x 10^{-5} in 10 hours; it then remained constant at 1.62290 during the remaining 40 hours of the treatment. Concurrently, the birefringence, after a slight decrease during the first hours, remained constant throughout the heat treatment. Near the 25th hour, a heating incident caused a temporary slight shift of refractive index and a few analogous oscillations of the birefringence.

Finally, an experiment made on a dense barium-crown at 650°C. (Fig. 16) showed that, as temperatures neared the upper limit of the transformation range, the limit value of the birefringence approached closer to zero.

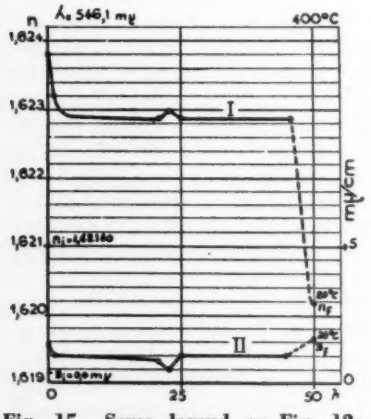

Fig. 15. Same legend as Fig. 12: dense flint at 400°C.

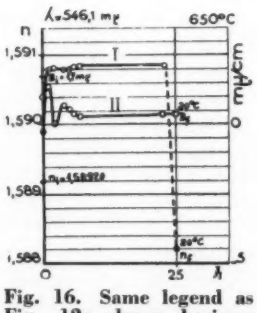

Fig. 16. Same legend as Fig. 12: dense barium-crown at 650°C.

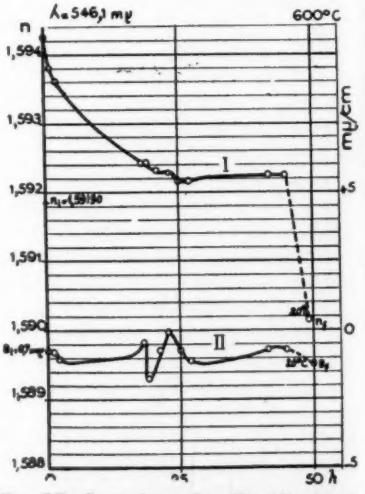

Fig. 17. Same legend as Fig 12: dense barium-crown at 600°C.

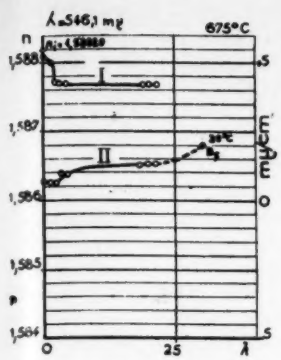

Fig. 18. Same legend as Fig. 12: dense barium-crown at 675° C.

It is interesting to foresee what the refractive index and birefringence values will be at 20°C. after cooling of a sample held sufficiently long at a temperature in the transformation range for it to take on the structural equilibrium determined by this temperature. The sample acquired a birefringence B and a refractive index n of equilibrium.

If the annealing temperature is close to the lower limit of the transformation range, the rate of transformation is low, particularly compared to the cooling rate. So, at the onset of cooling, the glass does not have the time to be transformed and hence traverses the temperature region where the transformation rate is low but appreciable without change of the structural state it had acquired during annealing. Once the elastic range is reached, the transformation rate becomes null and the glass keeps its structural state. So it can be foreseen that the cold glass will possess the birefringence B of equilibrium at the time of annealing, and a refractive index equal to that existing at the time of annealing, diminished by the temperature coefficient shift of index with the temperature from the annealing temperature to 20°C. This is the case of the dense flint maintained at 385°C. (Fig. 14) which, at 20°C., kept its stable birefringence 1.9 mμ/cm when hot and whose refractive index passed from $n_i = 1.62000$ before annealing to $n_f = 1.62075$ after annealing. This increase of 75 x 10^{-5} is of the same order as the growth (60 x 10^{-3}) of refractive index at 385°C. following a modification of structure by annealing.

If, on the contrary, the temperature of the thermal treatment is close to the upper end of the transformation range, the transformation rate is high and is of the same order as the cooling rate. The outer layers congeal in the structural state which they possessed during the treatment but the median and inner layers are transformed without having the time to acquire the stable state which corresponds to each of the successive temperatures taken by the sample. This inequilibrium goes on being accentuated up to the entry into the elastic range when the transformation rate can be considered as null. The cold glass shows a birefringence different from the birefringence B of equilibrium when hot and in general higher, and the refractive index possesses a much lower value than that of an annealed sample. The sample is said to be quenched.

The dense flint treated at 400°C. illustrates this way of thinking (Fig. 15). The stable birefringence limit at 400°C. (1 mμ/cm) was not maintained after cooling, and the sample acquired a birefringence of 1.8 mμ/cm at 20°C. The refractive index of n_f at 20°C. after the thermal treatment was 1.62020, i.e., 80 x 10^{-5} less than the value of $n_i = 1.62100$ before treatment. This glass lost its structural state of well-annealed glass. The same reasoning explains the behavior of the dense barium-crown kept at 600°C. and 675°C. whose curves of refractive index and birefringence are drawn in Fig. 17 and Fig. 18. The curves in dotted lines show the results of air cooling.

Table of Numerical Values

Numerical values recorded for refractive index ($\lambda = 546.1$ mμ) and birefringence corresponding to the seven figures shown in Part IV.

Time, Hours	Refractive Index	Birefringence, mμ/cm
DF at 300°C. (Fig. 12)		
0	1.62180	1.4
2	1.62180	0.4
3	1.62185	0.4
4	1.62185	2
22	1.62195	1.4
24	1.62195	2
26	1.62190	0.7
30	1.62190	1.4
47	1.62200	0.7
52	1.62205	0
77	1.62195	0.3
BSC at 400°C. (Fig. 13)		
0	1.51670	5
1	1.51675	2.5
4	1.51675	1.8
5	1.51685	2.2
6	1.51685	1
8	1.51685	2.7
23	1.51705	1.5
25	1.51710	1.8
28	1.51715	2.5
30	1.51710	3.7
52	1.51770	2.5
54	1.51775	2.6
56	1.51780	3
71	1.51800	2.7
73	1.51800	3.5
75	1.51800	3.5
77	1.51800	3
95	1.51800	3.7
143	1.51800	3
DF at 385°C. (Fig. 14)		
0	1.62250	0.7
3	1.62295	1.8
4	1.62295	1.8
5	1.62300	1.8
6	1.62305	1.8
21	1.62310	2.1
22	1.62310	1.8
24	1.62310	1.8
69	1.62310	1.8
DF at 400°C. (Fig. 15)		
0	1.62380	1.4
1	1.62320	1.0

Time, Hours	Refractive Index	Birefringence, mμ/cm
22	1.62290	0.8
24	1.62300	0.5
25	1.62290	1.1
46	1.62290	1.0
	DBC at 650°C. (Fig. 16)	
0	1.58990	1.1
1	1.59080	1.3
2	1.59085	0
4	1.59080	0.7
5	1.59080	0.6
6	1.59085	0.4
7	1.59085	0.3
23	1.59085	0.4
	DBC at 600°C. (Fig. 17)	
0	1.59425	0.7
1	1.59380	0.7
2	1.59360	1.0
18	1.59240	0.3
19	1.59240	1.7
21	1.59230	0.7
23	1.59230	0
25	1.59215	0.7
27	1.59215	1.0
42	1.59225	0.7
45	1.59225	0.7
	DBC at 675°C. (Fig. 18)	
0	1.58810	0.7
1	1.58800	0.7
2	1.58775	0.7
3	1.58770	1.0
4	1.58770	1.4
19	1.5770	1.4
20	1.5770	1.4
21	1.5770	1.4

Conclusion

The simultaneous study of the birefringence and refractive index as a function of temperature for a typical heating makes possible precise determination of certain properties of glass.

When the temperature is varied in the region where the glass behaves approximately as an elastic solid (that is as long as the maximum temperature of a heating cycle remains below the lower limit of the transformation range), the shifts in refractive index and birefringence as a function of temperature are reversible and reproducible with time, provided the glass is well-annealed. This is not true when the glass is brought to a temperature in the transformation range. The glass is said then to have a thermal history. The values of its physical constants, when measured upon return to room temperature, depend on the temperature reached in the transformation range, on the time it remained at this temperature and on the rate the glass was cooled from that temperature.

This is how the simultaneous shifts of refractive index and birefringence appear in the course of heating during passage from 20°C. to the temperature where the glass becomes fluid. The index increased in an approximately linear way with the temperature, until the lower limit of the transformation range is reached; in the transformation range the index decreased on increase in the temperature. The values of the temperature coefficient of the index depend on the nature of the glass, but the directions of index variation with temperature are the same regardless of the nature of the glass undergoing the thermal treatment.

The birefringence curve as a function of temperature follows exactly the variation of the thermal gradient which appears in the sample, as long as the temperature remains lower than the lower limit of the transformation range. The difference in temperature between the surface and the core of the sample increases when the temperature rises above 20°C., then passes a maximum function of the heating rate, and finally decreases until it reaches a constant value which defines the thermal gradient of the heating. The birefringence curve shows the same trend. The strain increases with the temperature up to a maximum corresponding to the gradient maximum then decreases to a constant value with the gradient. For temperatures located in the transformation range, the strain passes a very pronounced maximum and then tends very rapidly toward zero. Curves have been drawn plotting temperature against birefringence expressed in mμ/cm per degree of thermal gradient so as to eliminate the immediate effect of the gradient creating temporary strains. These curves show the abrupt variation of strain which is produced in the transformation range, as would be produced for the other physical constants.

When the glass is cooled, it retains the evidence of this transformation and its physical properties are modified (quenched glass) in relation to those it had at the beginning of heating (annealed glass). It is thus shown that permanent strain appears in the transformation range simultaneously with the variation in the physical constants of the glass. This appearance of strain can be explained only by changes in structure.

Studied at fixed temperature, the glass shows a similarity in shift of refractive index and birefringence, which is the manifestation of its thermal state.

For a well-annealed glass, heatings at temperatures below the lower limit of the transformation range are without any effect on the room temperature values of the physical constants. On the contrary, in the transformation range birefringence and refractive index tend toward limit values characteristic of structural equilibrium at these temperatures. The rates of establishment of equilibrium are a function of the temperature. They are not the same at the higher temperatures (where they are rapid) as at the low temperatures (where they are slow). It has not been possible up to now to establish any general law valid for the whole transformation range for heating as well as for cooling. When the glass is cooled, the refractive index shows a considerable drop in its value before heating (quenched glass); the absolute value of this drop is characteristic of the given glass. (*Continued on page* 688)

SUMMARIES OF GLASS CONFERENCE PAPERS

Glass Tank Regenerator Checkers, By W. F. Rochow

Balanced Packaging of Glass Containers, By R. O. Spalding

Glass Tank Regenerator Checkers

By W. F. Rochow

Harbison-Walker Refractories Company, Pittsburgh, Pa.

While certain inherent physical properties of refractories are especially desirable for the most efficient service as heat reservoirs in glass tank regenerators, the ability of checker brick to withstand the treatment imposed upon them is more significant. The combined properties of thermal conductivity, specific heat and density, as well as other properties of lesser importance, such as surface texture and resistance to glazing, are necessary for maximum heat absorption and release. In commercial refractories commonly used for checkers, one enhanced property may compensate for a deficiency in another.

Factors which contribute to the failure of the checker brick can be summarized as follows:

(1) Fluxing as the result of contact with batch carryover and volatile alkalies at operating temperatures is perhaps the most important destructive factor. The higher the temperature, the more pronounced will be the chemical reaction. Molten slags or fluxes from the ports and regenerator crowns frequently seriously damage the checkers.

(2) Clogging of the checkers in most instances is closely associated with fluxing. As the fluxing of the checkers progresses, the viscous slag freezes at the lower temperatures prevailing in the cooler zones of the settings. Lancing with air or steam can successfully remove such deposits. Spalling or disintegration of the brick can also cause clogging.

(3) Slabbing af alumina-silica refractories of various classes as the result of the formation of nephelite is another destructive factor caused by alkalies. The nephelite formation begins at the hot face of the brick and proceeds for a short distance inward. This can occur to a degree that causes shelling or slabbing due to the thermal expansion difference between the two layers. Some observations indicate that noselite, which is formed in the presence of sodium sulphate, causes a similar reaction.

(4) In the higher range of temperatures, for example 2100°F. to 2300°F., reducing gases, such as carbon monoxide, hydrogen and various hydrocarbons, can cause refractories to weaken appreciably. Free oxides of iron are most suspectible to the damaging effects of the reducing conditions. Alternate oxidizing and reducing conditions seem to intensify the action. Basic refractories are more susceptible to damage under these conditions than are the alumina-silica brick, but their greater resistance to the other destructive factors accounts for their extensive use in air checkers.

(5) Steam, especially under some pressure, can cause the magnesia in basic refractories to hydrate, thus weakening the bond of the refractory.

(6) The checker brick obviously must have adequate strength to sustain the load imposed upon them at operating temperatures. However, after long continued service, alumina-silica brick become impregnated with alkalies, with the resultant marked decrease in high temperature strength.

Refractories suitable for glass regenator checkers comprise a wide range of types and classes. High-duty fireclay brick used for moderate conditions are economical under more refractory checkers and also in the setting at the cooler ports where the treatment is less severe.

Semi-silica fireclay brick may find some advantageous use in this application on the theory that fluxing may occur slowly enough with a resultant highly fluid glass that will not freeze within the checker settings. This type of brick, improved over the conventional type, are now on trial.

Super-duty fireclay brick of both normal and extra hard burns (greater mullite development) are extensively used as checker brick in glass tank regenerators. The high-alumina classes of brick (alumina contents of 50%, 60%, 70%, 80% and 90%) are most likely to prove economical in applications where the refractoriness of

CHECKER DATA
CONVENTIONAL OPEN SETTING

UNIT DATA	9"x4½"x2½" ST.	9"x4½"x3" ST.	9"x6"x3" ST.	9"x6"x3" ST.	10"x6"x3" ST.
SIZE OF VERTICAL FLUES	6"x6"	6"x6"	6"x6"	6"x6"	6"x6"
NO. OF PCS. PER CU. FT. CHECKERWORK	4.74	4.74	3.56	2.37	1.78
9" EQUIVALENT PER CU. FT CHECKERWORK	3.05	6.06	6.06	6.06	6.06
TOTAL SQ. FT. HEATING SURFACE PER CU. FT. CHECKWK.	3.74	3.85	3.56	3.56	3.56
EFFECTIVE SQ. FT. HEATING SURFACE PER CU. FT. CHECKERWORK	1.93	1.78	1.78	1.78	1.78
PERCENT SOLID BRICK	27.8	33.3	33.3	33.3	33.3
PERCENT HORIZONTAL FREE AREA	52.2	44.4	44.4	44.4	44.4

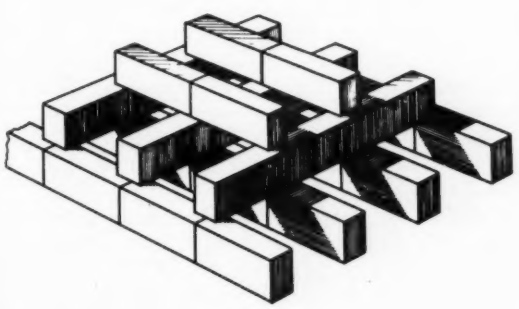

Fig. 1.

CHECKER DATA
SPACED BASKET WEAVE SETTING

UNIT DATA	12½x4½x2½ST	13½x4½x3ST	13½x6x3ST
SIZE OF VERTICAL FLUES	4½x4½	6x6	6x6
NO OF PCS PER CU FT CHECKERWORK	4.74	4.74	3.56
9" EQUIVALENT PER CU FT CHECKERWORK	7.58	9.1	9.1
EFFECTIVE SQ FT OF HEATING SURFACE PER CU FT OF CHECKERWORK	3.85	3.56	3.96
PERCENT OF SOLID BRICK	41.7	50.0	50.0
PERCENT OF HORIZONTAL FREE AREA	52.2	44.4	44.4

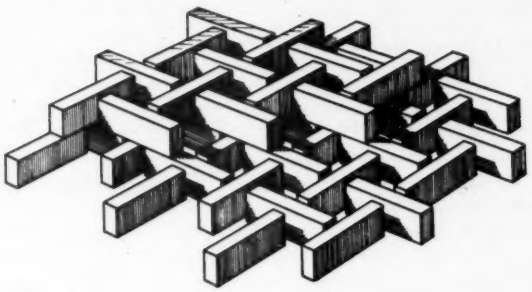

Fig. 2.

fireclay brick has proven to be inadequate. Special glass compositions may also dictate their use.

Especially in some borosilicate glass tank regenerators, silica brick render unusually long service, and at their relatively low cost, their use is very economical. Adequate checker chamber capacity is of paramount importance in connection with the successful use of silica brick in these particular instances.

While most of the various classes of commercial basic refractories have been tried in checker settings or in regenerator walls, arches, uptakes and ports, certain kinds of basic refractories have become perhaps more extensively used than any others in the most vulnerable portions of checker settings.

Two types of forsterite refractories, consisting predominantly of magnesium silicate, have become most widely used because of their high resistance to fluxing and wetting, as well as their rigidity and stability under the conditions prevailing in checker chambers. One of these is the "conventional", so-called because it has been commercially available for a long time. The other is a modification and is made by the addition of a mineralizer which increases its resistance to reducing atmospheres and enhances some of the other desirable physical properties.

Chemically-bonded magnesite-chrome refractories in some instances give a good account of themselves. Over a wide range of temperatures, their strength is not retained to the same high degree as in the case of pre-fired basic brick. A hard-fired magnesite-chrome refractory with the same composition as the chemically-bonded is now under trial. The same refractory, with added mineralizer which increases resistance to reducing conditions or to alternate reducing and oxidizing conditions, is also available and holds considerable promise.

The conventional hard-burned magnesite brick, having a magnesia content of about 90%, and also the periclase refractory containing about 95% magnesia have been used to advantage in certain checker settings. Finely divided silica carry-over may have had a harmful effect on them in some cases.

Because of the widely varying conditions imposed upon the refractories in glass tank regenerators, it is not practicable to enumerate service life except in relative terms. In some cases, a life of several months may be economical, while in others a life of several campaigns may be reasonable expectancy.

The actual economy in the salvage of checkers has always been a questionable matter. In some instances, a considerable saving has resulted in the reuse of hard-fired basic refractories which have been in use. More than 35% have been recovered for reuse in the lower portion of the settings.

In the case of hot checker repair, there have been occasions of successful hot checker replacements with forsterite checkers. In several cases, the procedure has been to reduce tank temperatures to about 2000°F. to avoid overheating the checkers on the hot side. After the checkers have been replaced, the reversals were commenced on a five-minute cycle to slowly heat the cold checkers. The reversal cycles were gradually increased over a period of about 48 hours, at which time the tank was up to normal operating temperatures.

Adequate checker space and advantageous setting systems for the conditions involved naturally are extremely important in securing high efficiency and long service. The sizes of the checker brick used may vary widely to provide the most desirable open space, exposed surface and over-all volume of refractory. The conventional open setting and its unit data are shown in Fig. 1, while Fig. 2 shows the spaced basket weave setting.

Balanced Packaging of Filled Glass Containers

By R. O. Spalding

Owens-Illinois Glass Company, Toledo, Ohio

The best way of illustrating exactly what is meant by "balanced packaging" is to cite an example that occurred during World War II. For years the standard box that was used in the liquor industry consisted of a 200 lb. test outer, 200 lb. test liner, 200 lb. test top and bottom pads and a 200 lb. test partition. This box has been used for all size bottles and was the box called for in the railroad's shipping regulations. During the war, paper became so scarce that the railroads relaxed their rules and permitted the use of non-test inner packing; that is, liners, pads and partitions. This weakened the boxes and claims started to mount, especially on the larger capacities; namely, fifths and quarts. At the war's end, the glass container industry started a research program to see if they couldn't find a better package for such shipments. In

(*Continued on page* 684)

Inventions and Inventors

Glass Compositions

Glass Sheet Containing Translucent Linear Strips. Patent No. 2,682,134. Filed August 17, 1951. Issued June 29, 1954. One sheet of drawings (none reproduced). Assigned to Corning Glass Works by Stanley D. Stookey.

This invention relates to glass sheets having clear or transparent linear portions and translucent linear portions particularly suitable for use as louvered windows. Articles of this type are formed by suitably exposing selected portions of a transparent photosentitively opacifiable glass to short-wave radiations and thereafter heating the glass to cause precipitation of light-diffusing crystallites in the exposed portions. The following batches are illustrative of glass compositions which are suitable for making such glass sheets (weights in grams except the gold solution, which is expressed in cubic centimenters):

	1	2	3	4
Sand	1,000	1,000	1,000	1,000
Na_2CO_3	370	346	19	143
$NaNO_3$	...	39	17	47
K_2CO_3	...	...	...	177
Li_2CO_3	...	...	390	...
$BaCO_3$	...	...	160	555
Al $(OH)_3$	225	225	42	50
Borax (anhydrous)	12.5	22	...	...
AgCl	...	...	1.1	...
$AgNO_3$	0.03	...	...	...
Gold solution (10% Au)	...	0.3	...	1.2
Cerium Hydrate (75% CeO_2)	0.2	0.22	0.32	0.8
Sb_2O_3	1.4	1.37	...	0.2
Na_2SiF_6	71	72	5.6	...
NaBr	5.0	...	...	...
NaCl	...	3	...	...

The gold solution is prepared by dissolving metallic gold in aqua regia in the proportions of 10 grams of gold per 100 cc. of solution.

To the above batches are added 0.01% to 0.3% NiO and 0.001% to 0.03% CoO on the oxide basis. Smaller amounts of NiO and CoO are ineffective for reducing glare. Larger amounts of these oxides lower the transmission of the clear portions of the glass sheet below 70% for a 3 mm. thickness, beyond which point the glass becomes objectionably colored.

The patent contains 2 claims and the following references were cited: 2,515,940, Stookey, July 18, 1950; 2,515,943, Stookey, July 18, 1950; 2,581,639, Duncan, Jan. 8, 1952; and *Ceramic Industry*, vol. 44, No. 1, January 1945, pages 83 and 99.

Opalescent Ivory-Colored Glass. Patent No. 2,683,666. Filed September 26, 1951. Issued July 13, 1954. No drawings. Assigned to Pittsburgh Plate Glass Company by James E. Duncan and Samuel L. Seymour.

Difficulty has been experienced in compounding a glass having an ivory color which will be satisfactory to the trade. Many attempts have been made to produce an opalescent glass with a color comparable to that imparted by the combination of uranium and selenium oxides, materials not now available for this purpose, without success. Titanium dioxide, cerium oxide and fluorine are necessary to attain the desired ivory color. Typical glass batches giving desirable results are shown in Table I.

Table I

Constituent	I	II	III
Sand	918	918	818
Soda Ash	327	327	235
Nepheline Syenite	271	271	253
Fluorspar	11	11	11
Sodium Nitrate	30	30	30
Sodium Silicofluoride	132	132	195
Arsenic Trioxide	10	10	10
Titanium Dioxide	68	85	150
Cerium Hydrate	20	25	44

The patent contains 4 claims and the following reference was cited: 2,444,976, Brown, July 13, 1947.

Glass for Embedding Zinc Sulphide Phosphors, Patent No. 2,681,861. Filed December 12, 1950. Issued June 22, 1954. One sheet of drawings (none reproduced). Assigned to Westinghouse Electric Corporation by Walter J. Hushley.

This invention relates to screen presenting extended areas of phosphors such as zinc sulphide, and provides a novel kind of protective matrix. The embedding glass is ground to a powder capable of passing through a sieve having 100 to 200 meshes per inch, preferably 150 mesh. It is then mixed with approximately equal weight of an X-ray phosphor powder such as zinc sulphide which has particle sizes averaging about 200 microns. This mixture is then deposited evenly to a thickness of about 100 mg. per square centimeter on a supporting glass.

Glasses which may be used for embedding inorganic phosphors, such as zinc sulphide, can be made according to the formula given below:

No——	1	2	3	4	5	6	7	8
Comp:								
B_2O_3	55	44	66	60	80	60	70	75
SiO_2	20	16	20	25	10	15	14	15
Al_2O_3	10	8	3	3	3	6	..	2
MgO	..	..	2	..	..	3	6	2
BeO	..	..	..	..	2	2	..	..
Li_2O	..	..	2	4	2	3	..	3
Na_2O	5	4	5	4	3	..	6	3
K_2O	5	4	2	4	..	7	5	..
NaF	5	4	..	..	..	4	4	..
GeO_2	..	20	..	..	..	..	..	..

The patent contains five claims and the following references were cited: 2,523,264, Armistead, Sept. 26, 1950 and 2,573,200, Hushley, Oct. 30, 1951.

Glass Wool and Fibers

Coating Glass Fibers with Unsaturated Polysiloxanolate and Article Produced Thereby. Patent No. 2,683,097. Filed April 17, 1951. Issued July 6, 1954. No drawings. Assigned to Owens-Corning Fiberglas Corporation by Lawrence P. Biefeld.

Because of the hydrophilic nature and the perfectly smooth non-absorbent characteristics of glass fiber surfaces, it has been difficult to achieve strong adhesion or integration of resinous materials to the surfaces of glass fibers. When exposed to high humidity conditions, the adhesion of the resinous material for the glass fiber surface is further lessened by the displacement of the resinous coating by what appears to be a film of water.

An improved treatment of glass fibers for resinous adhesion is as follows: A textile fabric of glass fibers is heat cleaned to remove the size and then immersed for 5 minutes in a 1 per cent water solution of sodium allyl polysiloxanolate prepared by the addition of hydrochloric acid to a more concentrated water solution of the polysiloxane having a pH of about 10-12 and adjusted back with sodium hydroxide to a pH of 7. The treated fibers are allowed to air dry and then rinsed in cold tap water to rinse off soluble salts formed by the pH adjustment. Although one treatment ordinarily is sufficient, the process may be repeated one or more times to build up higher concentrations of the unsaturated polysiloxanolates on the glass fiber surfaces. Thereafter the treated fabric is heated at a temperature of about 212-230°F. 15 min.

The patent contains 13 claims and the following references were cited: 2,392,805, Biefield, Jan. 15, 1946; 2,507,200, Elliott et al., May 9, 1950; 2,513,268, Steinman, June 27, 1950; 2,563,288, Steinman, Aug. 7, 1951; and 2,587,636, MacMullen, Mar. 4, 1952.

Method of Filling Open Mesh Glass Cloth with Colloidal Asbestos Fibers and Article Produced. Patent No. 2,681,870. Filed June 19, 1951. Issued June 22, 1954. One sheet or drawings (none reproduced). Assigned to Raybestos-Manhattan, Inc. by Izador J. Novak.

This invention relates to a composite comprised of glass fibers and asbestos fibers, and more particularly to a fabric of open mesh woven glass cloth. The combination of glass fiber and asbestos fiber is a most advantageous one whereby the disadvantages of one are compensated by the advantages of the other. For example, materials composed essentially or primarily of glass fibers while having high tensile strength are subject to disintegration by vibration or friction, such as may occur in electrical installations; and further, as is well-known, the heat resistance of glass is limited by its melting point. On the other hand, although asbestos products may have relatively little tensile strength, they have high heat and flame resistance and maintain their fibrous character without melting at temperatures far beyond the melting point of glass. Further, by employing a colloidal dispersion of asbestos, the dried residue is characterized by such previous colloidal dispersion and a mixture of extremely fine fibers which forms a fine uniform coat for the glass fibers and protects the susceptibility of the glass to break down by vibration or friction.

Application of the asbestos takes place on a paper-making machine which may employ a wire screen or a paper-making felt, wherein glass cloth, preferably open mesh, is continuously fed to the porous carrier and the viscous colloidal asbestos dispersion applied by a spreading technique to the opposed sides of the mesh cloth, after which the composite of applied material and cloth is dried on a drying drum or in a drying chamber.

The patent contains 7 claims and the following references were cited: 1,505,694, Bentel, Aug. 19, 1924; 2,114,618, Wallin, Apr. 19, 1938; 2,215,150, Hannen, Sept. 17, 1940; 2,216,759, Simison, Oct. 8, 1940; 2,230,271, Simpson, Feb. 4, 1941; 2,298,295, Hyatt et al., Oct. 13, 1942; and 2,546,230, Modigliani, Mar. 27, 1951.

Sheet and Plate Glass

Apparatus for Surfacing of Both Faces of a Ribbon of Glass. Fig. 1. Patent No. 2,679,127. Filed May 14, 1952. Issued May 25, 1954. Six sheets of drawings. Assigned to Les Glaceries de la Sambre, Societe Anonyme by Edmond Laverdisse.

The present invention concerns the simultaneous surfacing (i.e. grinding and or polishing) of the two faces of a continuous ribbon of glass by means of tools in the form of rotating discs which are mounted on supports or beams disposed transversely in relation to the ribbon of glass, as shown in Fig. 1.

The continuous ribbon of glass 1 leaving an annealing furnace is conveyed in known manner on horizontal rollers 2 successively through a grinding apparatus and through a polishing apparatus.

The upper working tools 3 and the lower working tools 3′, actuated with a rotational movement, are supported by beams 4, 5 arranged in pairs, one above and the other

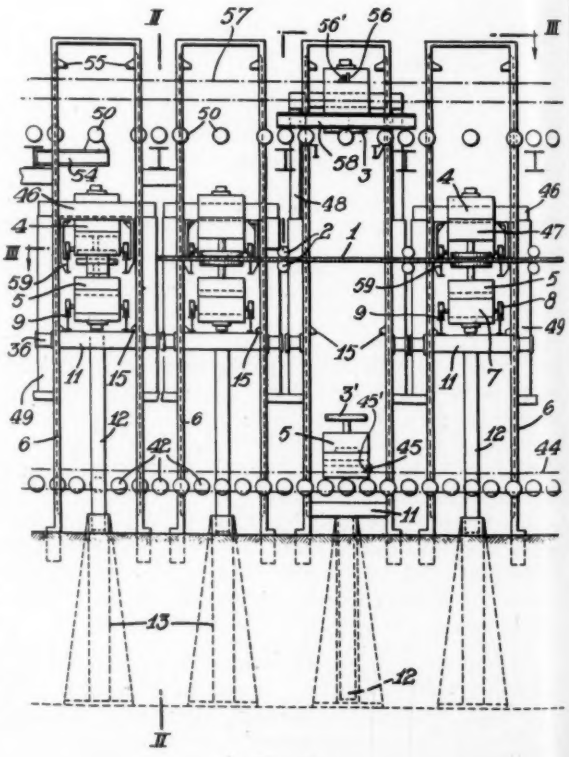

Fig. 1.

below the glass 1, so as to work the two faces simultaneously. Each pair of beams is actuated with a reciprocating movement transversely in relation to the ribbon of glass and is supported in frames or a framework constituting vertical slideways 6 for the supports of the beams.

Each lower beam 5 rests at its ends on carriage 7, the carrying rollers 8 of which travel along horizontal tracks 9 mounted on supports 10 (not shown) connected to plates 11 supported by the rods of hydraulic pistons 12 adapted to slide in cylinders 13.

Hand levers 22 and 33 (not shown) are operated when it is desired to withdraw a beam 5 for the purpose of cleaning or replacing it, these operations taking place without interrupting the advance of the sheet of glass.

The patent contains 12 claims and the following references were cited: 1,989,408, Goodwillie, Jan. 29, 1935; 2,341,524, Bezborodko et al., Feb. 15, 1944; and 660,248, Great Britain, Oct. 31, 1951.

Miscellaneous Processes

Apparatus for Coating Hollow Glassware. Fig. 2. Patent No. 2,679,822. Filed June 29, 1950. Issued June 1, 1954. One sheet of drawings. Assigned to General Electric Company by Robert A. Kuebler.

The apparatus shown in the drawing provides for the deposition of a light-diffusing material directly on the inner surface of a vitreous bulb 1 for an electric incandescent lamp immediately upon the formation of the light-diffusing material in the flame of the burner 2. During the entire cycle of operation, a relative rotative motion occurs between the bulb 1 and the burner 2 in that the holder 4 is rotated through a belt 12 engaging a sheave 13 on the lower end of the main body 11 which extends through and is supported by the bracket 14.

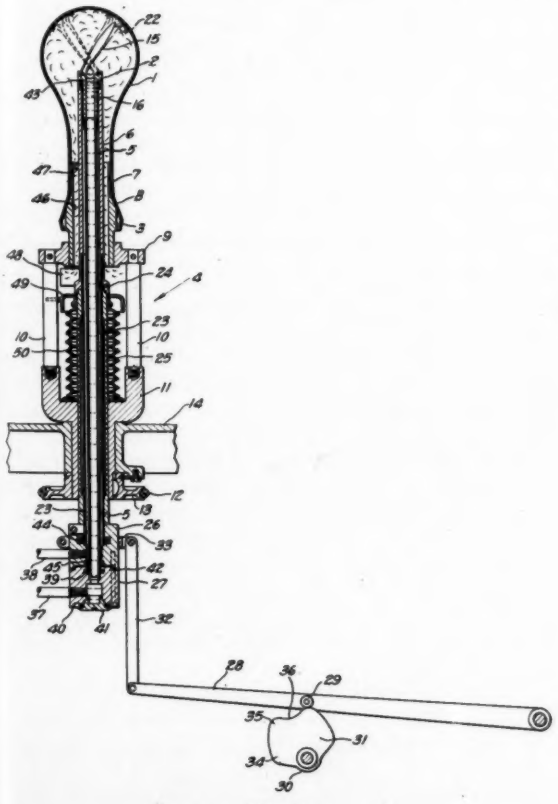

Fig. 2.

The light-diffusing material deposited upon the interior surface of the bulb 1 is the product of a controlled burning of ethyl silicate vapors in the presence of oxygen and air and first appears in the apparatus in the form of a fume thrown off from the flame 15 over the upper end of the burner 2. Heat absorbed by the burner 2 from the flames 15 causes liquid ethyl silicate located within a relatively large central well 16 to boil off as a vapor which burns over the upper end. The patent is particularly applicable to the process revealed by Marvin Pipkin in Patent No. 2,545,896.

The patent contains 1 claim and 10 references were cited.

Molten Glass Viscosity Measuring Apparatus. Fig. 3. Patent No. 2,679,749. Filed October 30, 1948. Issued June 1, 1954. One sheet of drawings. Assigned to Brockway Glass Company by James P. Poole.

This invention relates to apparatus for measuring the viscosity of molten glass. The operation of the apparatus is as follows. With bait element 16 in the position illustrated in Fig. 3, out of contact with the molten glass charge which is designated 40 in Fig. 3, control circuit 31, 34 is de-energized and relay 38 is so arranged that under these circumstances motor 25 operates to move push rod 20 in a downward direction through rotation of pinion 27. This movement continues until the tip 17 of bait element 16 contacts the glass charge 40 whereupon control conductors 31, 34 become energized by a circuit which extends from tip 17 through the glass charge 40 to electrode 32. This energizes the relay of reversing switch 38 to reverse the direction of motor 25 and thus cause bait element 16 to move upwardly.

Upon such upward movement, bait element 16 will draw a fiber from the glass charge and the length of the fiber thus drawn gives an absolute determination of the viscosity of the glass charge. The height of bait element 16 and push rod 20, or more properly the distance between the lower end of bait element 16 and the upper surface of glass charge 40 at the moment when the fiber thus drawn breaks from the glass charge 40, indicates the viscosity of the glass charge 40. Since motor 25 is preferably of the synchronous type, the time duration of

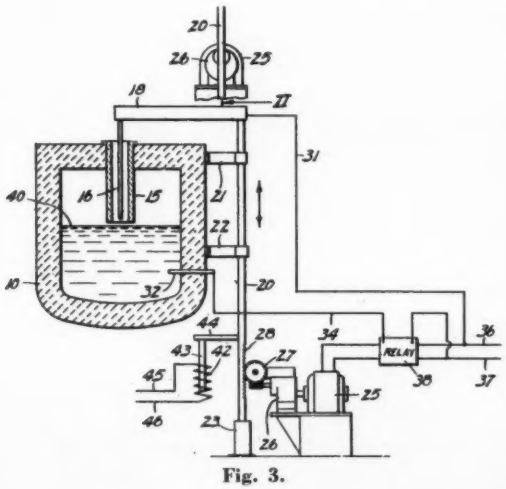

Fig. 3.

this upward movement is likewise an indication of viscosity, since it is directly proportional to the length of the fiber drawn.

The patent contains 1 claim and 10 references were cited.

Method of Treating Glass Cloth. Fig. 4. Patent No. 2,674,548. Filed May 28, 1951. Issued April 6, 1954. Three sheets of drawings. Assigned to Glass Fibers Inc. by Emil H. Balz.

This invention relates to a treatment for glass cloth to render the same useful in the making of laminations with resinous materials.

Referring to Fig. 4, the roll of glass cloth 1 is shown mounted upon a stand 2 and may be appropriately unreeled and passed over an idler roller 3 into a tank 4 containing an acqueous 0.1 to 1% solution of sodium hydroxide having a pH of 11-13 and indicated generally at 5. The cloth is rerolled in the solution on stand 6 and permitted to soak for about 1 hour whereupon it is removed from the alkaline solution and stored as at 7 to await further processing. The alkali treatment removes a portion of the starch, as well as soluble borax and gelatin, and renders the binder remaining on the cloth readily susceptible to the temperature treatment.

The alkali-treated roll is washed of excess alkali by water sprays indicated at 15. The washed cloth upon leaving the water spray is passed under a spreader roll 17 and on to oven 18, which operates at a temperature of approximately 750°F. to 800°F. where a conveyor indicated at 19, driven through power means denoted at 20, supplies motive power to the cloth.

The heated glass cloth containing the binder material residue is then passed continuously into a tank 21 containing a 0.5% aqueous solution of sodium hypochlorite and having a temperature of about 75° to 80°F. Upon completion of the bleaching treatment, the excess bleaching agent is washed from the cloth with water having a temperature in the range of 150° to 170°F. by passing over rolls 24, 25, 26 and then dried in oven 28 and rolled up on reel stand 29. A completely cleaned glass cloth is attained in an over-all production time for a given roll of less than about 2½ to 3 hours.

The cleaned glass cloth thus produced will laminate readily with silicone resin and when the cleaned cloth is first treated with a cationic agent, such as Volan, a bond with the polyesters may be effected.

The patent contains 13 claims and the following reference was cited: 2,407,483, Ebaugh, Sept. 10, 1946.

Glass Cutting Apparatus. Fig. 5. Patent No. 2,675,648. Filed December 29, 1952. Issued April 20, 1954. Two sheets of drawings. Assigned to Fabricacion de Maquinas by John Martin.

The primary object of this invention is to provide an automatic "crack-off" machine in which no initial scoring or cutting of the hollow glass article is necessary.

Hollow glass articles, such as 31, Fig. 5, are placed upon the conveyor portion of the machine at the loading end. The desired point of crack-off is indicated by the dotted line 32 and that portion above the line of crack-off is known as the cullet. The conveyor serves to roll the hollow glass forms along the length of the machine. The rear guide member 30 is, of course, first adjusted to a position which will place the desired point of crack-off of the glass article in contact with the heated wire 11. In order to assure a rolling contact between the glassware and the wire, the relative positions of the lugs 22 and hence the chains 20 and 21 must first be adjusted.

Once the articles are loaded upon the machine, the operation is entirely automatic. Each article in rolling upon the heated wire 11 has a high thermal stress set up at the point of contact between the article and the heated wire. As the article makes at least one complete revolution in traveling through the machine, a desired crack-off of the cullet is automatically effected.

The patent contains 8 claims and the following references were cited: 317,805, Lange et al., May 12, 1885; 1,473,675, Halversen, Nov. 13, 1923; 1,652,959, Rolland, Dec. 13, 1927; 1,719,588, Campbell et al., July 2, 1929; 1,920,528, Butler et al., Aug. 1, 1933; 1,973,546, Spinasse, Sept. 11, 1934; 2,410,931, Eisler, Nov. 12, 1946; 2,428,407, Auzin, Oct. 7, 1947; and 17,691, Great Britain, July 15, 1893.

Television Glass. Patent No. 2,676,109. Filed Decem-

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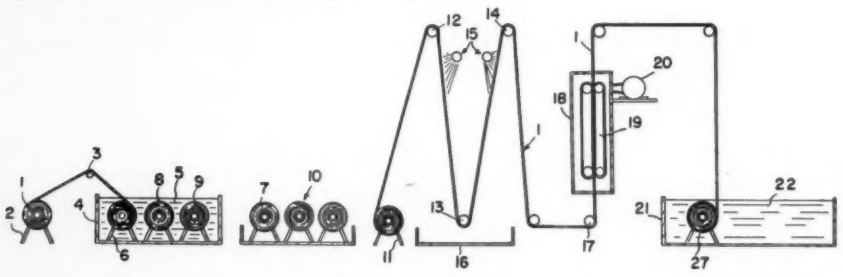


Fig. 4.

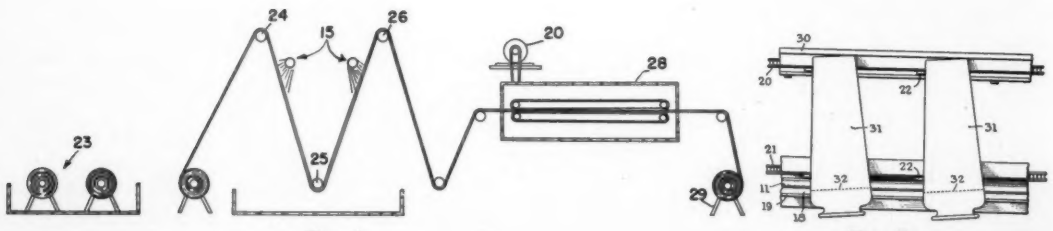


Fig. 5.

Research Digest

Contours Worn on Alumina-Silica Refractory Faces by Different Molten Glasses . . .

During the manufacture of glass, it is in the furnace that temperatures are hottest. Here the glass is most fluid and, therefore, offers least resistance to cohesion and adhesion, both of which are surface tension factors. In the April 1954 issue of the *Journal of the Society of Glass Technology*, H. J. Tress shows how such forces help to explain the attack of molten glass on refractories.

The author has founded a variety of glasses in open pots of ½ liter capacity made from mixtures composed partly or entirely of calcined kyanite and plastic white clays. The pots were matured at 1500°C. Often different kinds of refractory attack were encountered with different types of glass. Attack by the more fluid glasses was most marked and was examined further.

Molten glass gradually dissolves alumina-silica refractory and the glass, besides becoming richer in alumina, is also diluted by the refractory and as a result decreases in the proportion of fluxes present and usually in silica content.

The properties of solvent glass and refractory solution are contrasted in Table I.

TABLE I

Solvent Glass	Solution of Refractory
Markedly more fluid.	Markedly more viscous.
More erosive.	Less erosive.
More corrosive.	Less corrosive.
Lesser cohesion.	Greater cohesion.
Lesser surface tension.	Greater surface tension.
Penetrates easier into pores.	Penetrates more slowly into pores.

Increase of alumina at the expense of the corrosive fluxes raises viscosity and lessens chemical attack on the refractory. Consequently, the viscous film which slowly forms at the refractory face gives some protection to the solvent glass. The viscous aluminous film differs in density from the main solvent. In ordinary manufacture, this film is denser with a light glass, such as high borosilicate of low basic oxide content, but the lighter with a dense glass, such as low-silica lead glass.

In a dense glass at a uniform temperature, the lighter solution is pushed slowly upwards by unbalanced vitrostatic pressure. In a less dense glass, the process is reversed. To counteract accumulation and withdrawal of glass, currents, whatever their cause, are accompanied by return currents elsewhere and result in a continuous circulation.

Low silica slag glasses containing little or no alkali are reluctant to creep up an alumina-silica face and their large surface tension is little altered by dissolved refractory.

The large proportion of corrosive basic oxides causes pronounced and general pot attack everywhere beneath the glass. Falling glass level leaves the sidewall slanting backwards at the flux line. If the surface tension is altered by refractory solution, then surface forces may cause intensified attack near the glass line.

Most glasses, particularly those of very small surface tension, wet alumina-silica refractory. If the refractory be porous from inadequate firing, then it soaks up mobile glass by capillarity. Even with well-vitrified refractory, pin-holes may be formed at the ferruginous darker specks on the face.

Leadless low silicate, dense barium crown, lead barium borate, boric oxide and many other glasses spread up the refractory wall to form "arches". This phenomenon depends neither on the density nor the depth of the glass, but can be explained in terms of surface forces: a film of glass spreading up the pot side from the meniscus dissolves refractory and loses fluxes by evaporation. Consequently, as it creeps upwards, the film becomes more viscous and increases in surface tension. The viscous glass then draws more of the fluid solvent glass up from below. In this way, a band of aluminous glass gathers round the wall a centimeter or two above the glass line. This then shrinks at intervals into waists just as a jet of liquid breaks into drops. Fresh glass still wells up the face from below swelling the bulges between the waists until the aluminous glass trickles down again into the main glass.

There is a continuous circulation of glass up inside the archways and down the columns back into the main glass. The mobile glass from below scours a shallow depression on the refractory face inside each archway. Behind the viscous columns, the wall is attacked to a less extent. A slotted flux-line attack results when columns stretch downwards and shield ridges at the glass line.

Another striking, yet more destructive kind of attack is the etching after some minutes of pits a couple of millimeters or so in diameter. This pitting occurs with fluid glass of small surface tension. As with arching, it is still encountered with shallow pools of glass a few millimeters deep and occurs irrespective of density with very light glasses containing boric oxide, with high-alkali low-silicate containing alumina, lime or lead oxide, and with very dense optical glass. It is immaterial whether the solution formed at the refractory face is lighter or heavier than the solvent glass.

Solvent glass at the meniscus, besides creeping up the pot wall, also tries to creep downwards where it meets the layer of aluminous solution against the submerged face. In the case of denser glasses, this aluminous layer is slowly moving upwards. Just beneath glass level, the aluminous solution drags away from the pot-side and gathers into threads because of its greater surface tension.

Jets of solvent glass penetrate between these threads and scour the sidewall at the flux line producing an aluminous film on the refractory face which is continuously drawn by cohesion into the surrounding aluminous solution. The jets of solvent eat a horizontal row of holes,

(*Continued on page* 692)

A.C.S. DEDICATES NEW BUILDING

The dedication ceremony for its newly completed ceramic office building was held December 4 by The American Ceramic Society. The new structure at 4055 N. High Street, Columbus, Ohio, stands at the crest of a shale cliff, above a small stream, in Ceramic Park.

Presiding at the program was the president of the Society, Ray W. Pafford. Speakers on the program included Howard Landis Bevis, President of Ohio State University; Clyde Williams, President and Director of Battelle Memorial Institute; Robert B. Breneman, Armstrong Cork Company and President of the Columbus Technical Council; Frank H. Riddle of Champion Spark Plug Company, past-President of the A.C.S. and Chairman of its Building Fund Committee; and the Rev. Raymond E. Dronsfield, pastor of Overbrook Presbyterian Church.

The new building houses business and publication offices of The American Ceramic Society, organized to foster the exchange of scientific and technical information on the manufacture of ceramic products. The structure, composed of ceramic materials, includes the use of glass, brick and clay tile, porcelain enamel and fiber glass.

AMERICAN POTASH NAMES RESEARCH DIRECTOR

Joseph C. Schumacher, until recently Vice President and Director of Research of Western Electrochemical Company, has joined American Potash & Chemical Corporation as Director of Research, according to an announcement by Peter Colefax, President.

In his new capacity, Mr. Schumacher will direct all research activities of the company and its subsidiaries under D. S. Dinsmoor, Vice President in charge of Research and Development. The announcement further said that Mr. Schumacher will continue as a Director of Western Electrochemical Company, in which American Potash & Chemical Corporation has a substantial interest.

FOOD MACHINERY & CHEMICAL OPENS NEW YORK EXPORT OFFICE

Food Machinery & Chemical Corporation has established corporate export offices in New York City to represent the company's export lines of industrial and agricultural chemicals and various machinery items.

The new office at 161 East 42nd Street combines the export sales group of the firm's chemical divisions under the direction of Robert R. Clark, Manager of Chemical Export Sales, and a sales engineering staff representing various machinery divisions of the company.

L-O-F DIVISIONS AND GLASS FIBERS PLAN TO UNITE

A plan for uniting the Fiber Glass and Corrulux Divisions of Libbey-Owens-Ford Glass Company and the business and assets of Glass Fibers, Inc., into a well-integrated new organization to be known as Glass Fibers Corporation has been announced jointly by John D. Biggers, Chairman of Libbey-Owens-Ford, and Randolph H. Barnard, President of Glass Fibers, Inc. The plan will be submitted to the shareholders of Glass Fibers, Inc., for approval at an early date.

The new company will have five manufacturing plants in four states with more than 1,500 employees and a potential production capacity of $25,000,000 annually. Messrs. Biggers and Barnard stated that they believe this new development is very favorable for both companies, their shareholders, employees and customers. "The location and facilities of the plants of the two companies should supplement each other admirably," they stated.

L-O-F plants in Parkersburg, West Virginia, and Houston, Texas, are those that will be affected in the joining with Glass Fibers' plants in Waterville, Ohio, Defiance, Ohio, and Burbank, California. L-O-F will acquire 53% of the shares of the stock of the new Glass Fibers Corporation in exchange for its Fiber Glass and Corrulux properties, and Glass Fibers, Inc., 47% for its business and assets. The number of shares to be issued will permit shareholders of Glass Fibers, Inc., to have one share of stock in the new corporation for each share of Glass Fibers, Inc., now held.

"In addition, L-O-F has agreed to purchase up to $2,000,000 in 5% debentures of the new company, convertible into common shares at the same prices as the outstanding debentures of Glass Fibers, Inc."

The Board of Directors of the new fiber glass manufacturing organization will be composed of appropriate representatives of each of the two new companies. It is the intention of both parties that Mr. Barnard will be President and chief executive officer of the new organization. Selection of other officials will be made as promptly as practical. It is hoped that all details can be completed by December 31.

PACKING WRAP-AROUND WINDSHIELDS

With wrap-around windshields announced for many 1955 automobile models, considerable interest has developed in the packaging of this fragile product.

The Pittsburgh Plate Glass depot in St. Louis is distributing its wrap-around windshield in corrugated boxes developed by Gaylord Container Corporation. The windshields arrive in bulk shipments of 25 and are then repacked in individual boxes.

After the bottom is sealed, three pads are inserted in the box and the windshield slipped into notches provided for the purpose. With the windshield in position, two pads are placed above it. Final closure is done with a hand stapling device.

• Jack Solon Associates has been retained as public relations counsel for Glass Fibers, Inc., according to an announcement by R. H. Barnard, President of the glass firm. The new counsel will handle community and financial-stockholder relations, along with corporate publicity.

Current Statistical Position of Glass

Employment and payrolls: Employment in the glass industry during September 1954 was as follows: *Flat Glass:* A preliminary 26,000 was reported for September, which is 5.2 per cent higher than the 24,700 persons employed during August. *Glass and Glassware, Pressed and Blown:* During September, 75,700 persons were employed. This is a drop of .6 per cent from the adjusted figure of 76,200 for August. *Glass Products Made of Purchased Glass:* A preliminary figure of 14,100 was reported for September, indicating a rise of 2.9 per cent over the 13,700 reported for the previous month.

Payrolls in the glass industry were as follows: *Flat Glass:* A preliminary figure of $11,204,700 was reported for September. This is 8.7 per cent higher than the August payrolls of $10,306,240. *Glass and Glassware, Pressed and Blown:* The preliminary payrolls of $23,523,270 reported for September indicate a rise of .6 per cent over the previous month's $23,368,254. *Glass Products Made of Purchased Glass:* During September, payrolls were estimated at $3,789,422. This is 3.3 per cent above the previous month's $3,666,485.

GLASS CONTAINER SHIPMENTS

(All Figures in Gross)

Narrow Neck Containers	October, 1954
Foods	1,121,000
Medicinal & Health Supplies	1,157,000
Chemicals, Household & Industrial	818,000
Beverages, Returnable	268,000
Beverages, Non-returnable	57,000
Beer, Returnable	58,000
Beer, Non-returnable	528,000
Liquors	1,009,000
Wines	399,000
Toiletries & Cosmetics	613,000
Sub-total (Narrow)	6,028,000
Wide Mouth Containers	
Foods	*2,895,000
Dairy Products	243,000
Medicinal & Health Supplies	417,000
Chemicals, Household & Industrial	185,000
Toiletries & Cosmetics	173,000
Packers' Tumblers	138,000
Sub-total (Wide)	4,051,000
Total Domestic	10,079,000
Export Shipments	275,000
TOTAL SHIPMENTS	10,354,000

* This figure includes Fruit Jars and Jelly Glasses.

GLASS CONTAINER PRODUCTION AND INVENTORY

(All Figures in Gross)

		Production October 1954	Stocks October 1954
Foods; Medicinal & Health Supplies; Chemicals, Household & Industrial; Toiletries and Cosmetics	Narrow Neck	3,941,000	4,446,000
	Wide Mouth	*4,025,000	*4,338,000
Dairy Products		283,000	301,000
Beverages, Returnable		260,000	1,332,000
Beverages, Non-returnable		44,000	201,000
Beer, Returnable		94,000	451,000
Beer, Non-returnable		522,000	793,000
Liquors		1,075,000	1,135,000
Wines		402,000	466,000
Packers' Tumblers		197,000	221,000
TOTAL		10,843,000	13,684,000

* This figure includes Fruit Jars and Jelly Glasses.

Glass container production, based on figures released by the Bureau of Census, was reported to be 10,843,000 gross during October 1954. This is an increase of 9.7 per cent over the previous month's 9,883,000 gross. During October 1953, production was 11,088,000 gross, or 2.2 per cent higher than for October this year. At the end of the January-October 1954 period, glass container manufacturers have produced a total of 106,914,616 gross. Compared with the corresponding period in 1953 when total production was 104,509,998 gross, a difference of 2.3 per cent is shown.

Shipments of glass containers during October 1954 were 10,354,000 gross, or 4.5 per cent below September shipments, which were 10,853,000 gross. Shipments of glass containers during October 1953 were 10,514,000 gross. This is 1.5 per cent higher than for October this year. Total glass container shipments thus far in 1954 are 103,605,195 gross. This is .8 per cent higher than the 102,685,072 gross shipped during the same period in 1953.

Stocks on hand at the end of October 1954 were 13,684,000 gross. This is 2.8 per cent higher than the 13,299,000 gross on hand at the end of September and 24.4 per cent higher than the 10,996,000 gross at the end of October 1953.

Automatic tumbler production during September 1954 was 5,122,419 dozens. This is .1 per cent less than the August production of 5,131,368 dozens. During September 1953, production was 4,810,498 dozens. Shipments during September also fell off and were 4,768,140 dozens. This is 8.5 per cent less than the 5,213,395 dozens shipped during August. During September 1953, shipments were 4,785,245 dozens. Stocks on hand at the end of September 1954 were 9,036,474 dozens, or 4.4 per cent higher than the 8,651,645 dozens on hand at the end of August. Stocks at the end of September 1953 were 10,075,102 dozens.

Table, kitchen and household glassware: Manufacturer's sales of machine-made table, kitchen and household glassware during September 1954 were 3,503,309 dozens. This is 18.1 per cent above the 2,965,741 dozens sold during August. Sales during September 1953 were 3,792,654 dozens. At the close of the 12-month period ending September 1953, total sales had reached 36,895,153 dozens. This is 11.9 per cent below sales during the corresponding period ending September 1953 when manufacturers had sold 41,917,121 dozens.

TWO GLASS MEN NAMED OFFICERS OF K.A.B.

S. L. Rairdon

Two well-known men in the glass industry have been elected officers of Keep America Beautiful, Inc., a national organization for the prevention of litter.

Smith L. Rairdon, Vice President and Director of Marketing for Owens-Illinois Glass Company, has been elected first President of the group, and H. W. Kuni, Secretary-Treasurer of the Glass Container Manufacturers Institute, has been elected Treasurer.

Incorporated in December 1953 as a non-profit service group to encourage public action against the littering of roadsides, parks and other public areas, K.A.B. has, in the short span of its existence, gained impressive and widespread support from industry, public service groups, farm organizations, conservationist groups, women's organizations and youth organizations.

Other officers elected with Messrs. Rairdon and Kuni are William C. Stolk, President of the American Can Company, Chairman; W. B. Murphy, President of Campbell Soup Company, G. J. Ticoulat, Vice President, Crown Zellerbach Corporation, Vice Presidents; John R. Henry, American Can Company, Secretary.

IMPROVED G-E HEADLAMPS

A new, brighter, sealed-beam automobile headlamp, designed to increase visibility in clear weather but especially in rain, snow, fog and dust, has been introduced by General Electric Company.

Named the "All Weather" headlamp, General Electric's automotive lighting experts cite the following improvements: the high beam, or driving beam, gives 25 per cent more light; the low beam, or passing beam, produces about 23 per cent more light, and, more important, directs twice as much light down the right side of the road where it is needed most; the improved low beam greatly reduces the upward "spill" light which becomes blinding when it is reflected to the eyes by fog, snow, rain or dust; control of the lower beam is such that if the lamps are properly aimed, glare is reduced for approaching motorists in the critical passing zone.

PPG SALES APPOINTMENTS

Robert G. McNamara has been appointed sales representative for the Pittsburgh Corning Corporation, working out of the company's Philadelphia District Office. Mr. McNamara will assist distributors of PC glass blocks and Foamglas building and low temperature insulation, and act as advisor to architects, engineers and contractors concerning the application of these products.

Joining the sales staff of Pittsburgh Corning in the New England area is R. E. Cheney. Mr. Cheney will assist Robert Bygrove, of the Boston Office, in the sale and promotion of the same products as Mr. McNamara.

AMERICAN POTASH MAKES MAJOR PERSONNEL CHANGES

Three major personnel promotions have been made by American Potash & Chemical Corporation as a part of the company's current development and expansion program, it has been announced by Peter Colefax, President.

George S. Wheaton, formerly Assistant Vice President of the company's Eston Chemicals Division, has been promoted to Vice President in charge of that division. In addition to his responsibilities at Eston, Mr. Wheaton is active in American Lithium Chemicals, Inc., a recently-formed lithium manufacturing company controlled by American Potash. He will also have duties in connection with Western Electrochemical Company, in which American Potash has a substantial interest.

Thomas F. Edison, formerly Assistant Vice President of Research and Development, has been promoted to a newly-created position of Vice President in charge of Special Engineering Projects. He will be in charge of construction and initial production of the new $6,000,000 American Lithium Chemicals, Inc. manufacturing plant near San Antonio, Texas. Mr. Edison has been responsible for the selection of the lithium plant site and for engineering on the plant.

Richard J. Hefler, Secretary of the company, goes into a newly-created position of Assistant to the President. He will continue his duties as Secretary.

SYLVANIA NAMES TECHNICAL DIRECTOR

The appointment of Dr. Bennett S. Ellefson as Technical Director of Sylvania Electric Products, Inc. was announced by Howard L. Richardson, Vice President in charge of Engineering Operations. Dr. Ellefson succeeds E. Finley Carter, formerly Vice President and Technical Director of the company, who resigned to become the head of the research operations at Stanford Research Institute.

Dr. Ellefson, who has been Director of Research for Sylvania since 1946, will advise management on its research and engineering programs and will represent the company in high level, technical contacts with government and industry.

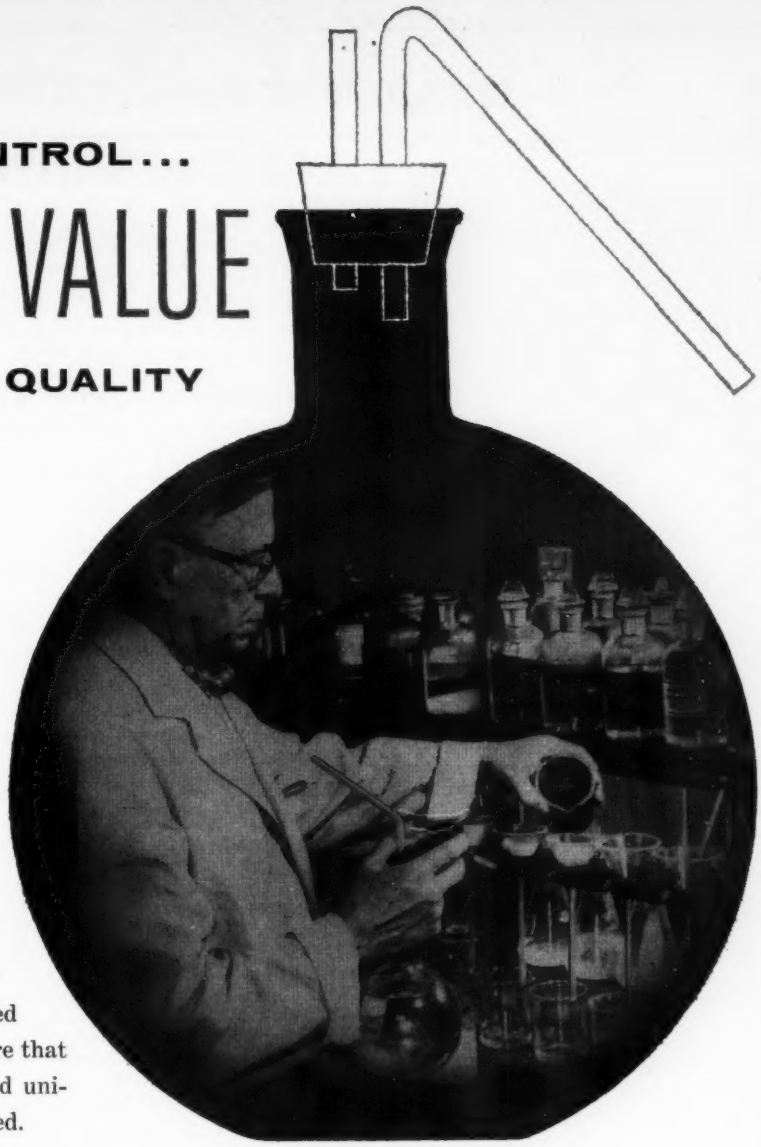
Joining the company in 1937, Dr. Ellefson started work at the Sylvania plant in St. Marys, Pa. as a research chemist, specializing in work on fluorescent materials and glass. He served in various engineering capacities until 1946 when he was appointed Director of the Central Engineering Laboratories on Long Island. During 1946, he served the Department of Commerce for three months in Germany as technical industrial intelligence investigator.

• Jervis C. Webb, President and General Manager of Jervis B. Webb Company, was elected President of the Conveyor Equipment Manufacturers Association at its recent 21st Annual Meeting at White Sulphur Springs.

CHEMICAL CONTROL...

INVISIBLE VALUE

IN COLORS OF QUALITY



Indispensable in color production at Drakenfeld is the full-time application of analytical chemistry. To guard against contaminants that can affect color quality, Drakenfeld chemists have at their command the most modern scientific laboratory equipment. Raw materials are tested on arrival and in process to assure that our high standards of purity and uniformity are constantly maintained.

Chemical control to aid production . . . studies of colors before and after application . . . technical help in solving color problems . . . research in anticipation of future trends . . . these are reasons why Drakenfeld Colors have won such a fine record for quality and economy among users over the years. If you are not acquainted with the advantages of Drakenfeld service, we invite you to obtain complete information.

DEPENDABLE SERVICE ON: Acid, Alkali and Sulphide Resistant Glass Colors and Enamels . . . Silver Paste . . . Crystal Ices . . . Squeegee and Printing Oils . . . Spraying and Banding Mediums . . . Glassmakers' Chemicals . . . Glass Decolorizers . . . Glass Frosting Compounds . . . Decorating Supplies.

CALL ON **Drakenfeld** — *OUR PARTNER IN SOLVING COLOR PROBLEMS*

B. F. DRAKENFELD & CO., INC.

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BRAUN CORPORATION, 2260 East Fifteenth Street
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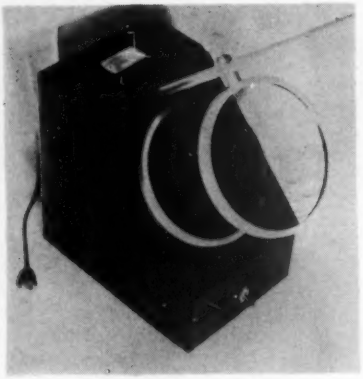
New Equipment and Supplies



POLARISCOPE; HOT WIRE GLASS CUTTER

Ronar, Inc., 1316 Sherman Avenue, Evanston, Illinois, is producing a polariscope and hot wire glass cutter, according to a recent announcement.

The polariscope is a low-cost unit consisting of a black metallized cabinet 7″ wide by 10″ deep by 10″ high, switch and cord for 110 V AC-DC, two polarized lenses 6″ in diameter, adjustable to 90° optical rotation. It weighs 7 lbs. The object being tested is placed between the two lenses and any existing strains will immediately reflect in sharp contrast.

The hot wire glass cutter is used for cutting soft or hard glass tubing up to 150 mm. in diameter. To heat the wire, plug into the special power supply unit which has a continuously variable AC voltage from 0 to 20 V at 7.5 Amps. The handle holds the wire and pulls it taut around the glass. The unit consists of black metallized power supply 9″ high by 5″ deep by 6″ wide. The special handle has 5 ft. of cord and 2 ft. of resistance wire.

OPTICAL PYROMETER

Epic, Inc., 154 Nassau Street, New York 38, New York, has announced the development of its H. & B. optical pyrometer used for the measurement of temperatures of glowing masses in annealing, hardening and calcining furnaces, of molten or flowing glass or metal, of red-hot ingots when forging, pressing or rolling.

The instrument is operated by a built-in storage battery and its range is from 1300° F. to 6300° F. It has a dust-proof housing and is easy to handle.

TWO-WIRE THERMOCOUPLE

Minneapolis-Honeywell Regulator Company, Industrial Division, Philadelphia, Pa., has announced a new two-wire thermocouple, encased in stainless steel tubing.

The new device is available with either of two types of terminal heads: an open head assembly or a screw-cover head. The latter comes in two sizes. The stainless steel protecting tube is expected to double the life of the new thermocouples. Accuracy of the new device is rated at plus or minus 5° F. over a range from 0° to 1000° F.

Fiber glass insulation in the new model thermocouples permits greater application flexibility than is possible with the ceramic-insulated types.

GLASS CUTTING BOARD

Red Devil Tools, Irvington, New Jersey, has announced a new glass cutting board vertically constructed and suitable for cutting panes up to 36″ x 36″.

To operate, the glass is inserted in the frame, the cutting handle is pulled, and the glass is quickly and accurately cut. Cutting does not require the use of a manual glass cutter as have previous models.

HAUCK COMBINATION BURNERS

Hauck Manufacturing Company, 124-136 Tenth Street, Brooklyn 15, New York, has announced something new for radiant tube firing in controlled atmosphere furnaces through its Series 630-P combination burners.

The flame length can be changed to fit the tube by means of the flame adjusting lever. More uniform heat distribution within a radiant tube is thus obtained. Either oil or gas can be burned with equally good results and quieter operation. Spark ignition gives easy and quiet lighting. The burner features are also advantageous in immersion tube firing applications.

CATALOGS RECEIVED

American Wheelabrator & Equipment Corporation, 1026 S. Byrkit Street, Mishawaka, Indiana, has issued a new 4-page bulletin, "How to Cut Die and Mold Finishing Time 50% to 94%".

The folder shows the application of wet blasting as done in the company's Liquamette machines to such cleaning and finishing work as is met in the manufacture and maintenance of various kinds of forming dies and molds. Illustrated cases with actual performance data are given, in addition to descriptions of the application of the process for glass molds, rubber molds, die casting dies, etc.

Wall Colmonoy Corporation, 19345 John R Street, Detroit 3, Michigan, is distributing a new engineering data sheet describing special properties of Colmonoy hard-facing alloys.

Data Sheet 1A presents a chart containing the red hardness curves of Colmonoy alloy No.'s 6, 5 and 4. The curves trace the approximate hardness of these nickel-base chrome-nickel-boron alloys at temperatures up to 1500° F. and show how such properties enable them to outwear hardened steel.

Also presented in the new data sheet are two tables for use in estimating hard-facing alloy material requirements. One table gives coverage obtained in square inches per pound of Colmonoy for eight different alloys in any of three overlay thicknesses. The second table shows the weight of Colmonoy in pounds required to overlay one square foot of the same alloys and overlay thicknesses.

The Hays Corporation, Michigan City, Indiana, has issued Publication 54-1060—210, featuring its diaphragm-operated vertiscale gages.

A completely new design in draft gages, the units can be employed for remote indication of pressure, flow, level, temperature, O_2 in flue gases, etc. Features include removable units, "one man" zero check, fluorescent lighting.

Johns-Manville, 22 East 40th Street, New York 16, New York, has issued a 6-page folder on Thermoflex, a multi-purpose refractory-fiber felt for service to 2000° F.

The folder presents essential data on the products, including its K factor, sound absorption qualities, chemical and thermal stability, densities, sizes and thicknesses. It can serve as a filter medium for hot gases and liquids, and is recommended as a sound control material. It may also be used as a refractory packing and fill.

Leeds & Northrup Company, 4934 Stenton Avenue, Philadelphia 44, Pa., has issued Data Sheet ND 46(4) giving concise information about Speedomax program control systems, which offer complete flexibility in setting the rate of heating, the length of the soak period and the rate of cooling in batch-type heating processes.

The sheet lists, in tabular form, the specific equipment required for each of five basic programming cycles, and the general equipment essential to a two-position or proportioning type of program control system.

Pittsburgh Corning Corporation, One Gateway Center, Pittsburgh 22, Pa., has issued a new 8-page catalog, "Skytrol Glass Blocks for Toplighting Your Buildings".

WHERE GLASS MANUFACTURERS USE B&W REFRACTORIES *for Longer Campaigns*

These glassmakers proved to themselves that B&W's specialized refractories paid off in longer campaigns. Why not use them in your tanks?

PLANT	LOCATION OF B&W REFRACTORIES
New York Manufacturer of Container Glass	B&W Dense 80 Firebrick in 1st & 2nd ports. B&W 80 Firebrick in checkers.
Ohio Manufacturer of Clear Glass	B&W 80 Firebrick in port construction, regenerator arches and walls, and top 8 to 10 courses of checkers. B&W Juniors in wall type checkers. B&W Allmul burner blocks.
Ohio Manufacturer of Container Glass and Colored Borosilicates	B&W Dense 80 and Junior Firebrick in checkers. B&W Dense 80's in burner block necks and B&W Juniors in ports.
Pennsylvania Manufacturer of Container Glass	B&W 80 Firebrick in ports, regenerator arches and walls as well as top 10 to 14 courses of checkers.
West Virginia Manufacturer of Glass for Fluorescent Lamps	B&W Junior Firebrick in checkers and ports.
Kentucky Manufacturer of Glass for Bulbs	B&W 80 Firebrick in ports, and B&W Junior Firebrick in checkers.
West Virginia Manufacturer of Plate and Window Glass	B&W 80 Firebrick in ports and regenerator crowns.
Pennsylvania Manufacturer of Container Glass	B&W Allmul Firebrick used in complete refining end.

PROPERTIES OF B&W HEAVY FIREBRICK

	B&W ALLMUL	B&W 80	B&W JUNIOR
Recommended use limit, F	3200	2950	2850
Fusion point, F	3335	3190	3173
Hot load strength, % deformation, 25 psi, 1½ hours	Less than 2% @ 3050F	Less than 1% @ 2640F	Less than 2% @ 2640F

BABCOCK & WILCOX

THE BABCOCK & WILCOX CO.
REFRACTORIES DIVISION
GENERAL OFFICES: 161 EAST 42ND ST., NEW YORK 17, N.Y.
WORKS: AUGUSTA, GA.

B&W REFRACTORIES PRODUCTS—B&W Allmul Firebrick • B&W 80 Firebrick • B&W Junior Firebrick • B&W Insulating Firebrick B&W Refractory Castables, Plastics and Mortars • OTHER B&W PRODUCTS—Stationary & Marine Boilers and Component Equipment... Chemical Recovery Units . . . Seamless & Welded Tubes . . . Pulverizers . . . Fuel Burning Equipment . . . Pressure Vessels . . . Alloy Castings

R475

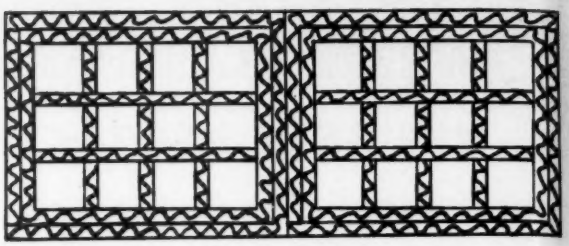
GLASS CONFERENCE SUMMARIES . . .

(*Continued from page 672*)

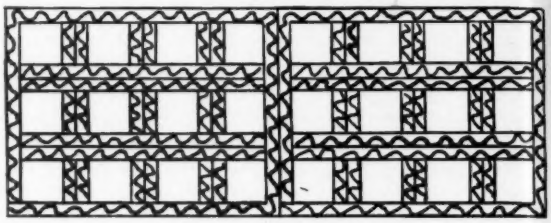
their research, they immediately found that the package required by the railroads was very unbalanced, and could be properly balanced very easily, and also that the new package was less costly than the one previously required.

Exactly what was done is shown in Fig. 1. This is a top view of the box formerly required by the railroads and shows the 200 lb. test outer, the 200 lb. test liner and the 200 lb. test partition. Assume that in a carload or a truckload shipment, or, for that matter, even in less than carload and less than truckload shipments, this box will move alongside another box just like it or another corrugated box. It becomes evident that we have four thicknesses of corrugated board between the outer rows of bottles in two adjacent boxes, but if we look inside the box, we find we have only one thickness of corrugated board between the bottles. Therefore, this box is just like a chain—breakage will occur at the weakest link. Laboratory tests proved that practically all the breakage in this type box was on the inside and had nothing to do with the amount of protection from the outside of the box to the first row of bottles. To balance this box, the 200 lb. test liner was removed and a double thickness partition put in. As shown in the figure, this makes two thicknesses of board between bottles inside the box, as well as two thicknesses of board between outside rows of bottles in adjacent boxes.

Another example concerns excessive breakage in what was thought a super-package. In this case, the outer was made of a double-wall material and the contents had a two-inch float of excelsior surrounding them. The bottles were in chipboard cartons containing one dozen units, but the bottles were only separated from one another by the flimsiest kind of chipboard partitions approximately 0.016 inch caliper. The result was super protection from the outside in, but practically no protection on the inside of the box. Therefore, under impact there was nothing to cushion the blows between bottles and this is where the breakage trouble was occurring. Redesigning the box and using corrugated separation between bottles lead to a marked improvement in packaging performance.



Unbalanced Packages



Balanced Packages

This theory of "balanced packaging" has many different applications. For example, in the case of a certain package, exhaustive laboratory test indicated that double thickness protection between the bottles was necessary, but the use of such considerably increased the cost of the package. It was, therefore, decided to use the double thickness protection only in one direction of the package; that is, the lengthwise direction where the impacts are normally received both in transit and handling. A policy was set up that all outbound cars would be loaded so that they would get the advantage of this double-thickness partition material. The length of the boxes always parallels the length of the car, and since impacts are normally received only in the lengthwise direction, advantage is taken of the increased cushioning.

Editor's Note: The above served as an introduction to the showing of a film presentation, "Balanced Packaging".

THATCHER APPOINTMENTS

Roger V. Rogers has been named Manager of the Detroit Office of Thatcher Glass Manufacturing Companny, according to an announcement by D. R. Parfitt, Vice President and General Sales Manager. Mr. Rogers replaced Bruce E. Sutton, who died recently after a brief illness.

Mr. Parfitt also announced the appointments of Raymond W. Roney and John C. Keagle to that company's glass container sales staff. Mr. Roney, who will work out of the Chicago office, joins Thatcher with a wide sales background in the glass container industry. Mr. Keagle, working out of Des Moines, Iowa, will represent Thatcher in several mid-western states. He attended Alfred University and prior to his new appointment, had been in Thatcher's Production Scheduling Department.

• Acheson Colloids Company, division of Acheson Industries, Inc., has announced the opening of a Rochester sales headquarters, located at 545 Powers Building. E. A. Lampman, service engineer, is territorial sales supervisor and will be in charge.

SALES MANAGER NAMED FOR TROPICAL GLASS

Anchor Hocking Glass Corporation has announced the appointment of Frank H. Baumgardner as Sales Manager of its subsidiary, the Tropical Glass & Box Company. It has also been announced that Philip W. Hatch has been named Sales Manager of the firm's Closure Division at Lancaster, Ohio.

WORLD'S FIRST SYNTHETIC MICA PLANT

The world's first synthetic mica plant, the beginning of a new industry which it is hoped will eventually reduce U.S. dependence on India for the highly strategic material, is under construction in Caldwell, New Jersey.

The new company, the Synthetic Mica Corporation, is scheduled to begin production early in 1955, according to Jerome Taishoff, President of the Mycalex Corporation of America, the parent firm. Estimated annual output of the new plant will be 1,000 tons of high-grade synthetic mica, about 5-10% of the nation's current requirement.

H. A. Youkers

W. B. Deible

KNOX APPOINTMENTS

H. A. Youkers has been named Director of Engineering for Knox group of companies, with headquarters in Knox, Pa.

Prior to returning to Knox, Mr. Youkers was employed as a Project Engineer by Lynch Corporation. From 1938 to 1950, he was associated with the Knox Glass companies as General Fabricating Engineer, coming to Knox at that time from Chicago Pneumatic Tool Company where he was employed as an Experimental Engineer.

Also announced was the appointment of William B. Deible as Chief Furnace and Construction Engineer.

He was employed as Plant Engineer by Metro Glass Bottle Company from 1946 to 1954 prior to joining Knox. From 1942 to 1946, Mr. Deible served in the Counter Intelligence Corps, U.S. Army, a portion of which time was devoted to the Jordanoff Aviation Corporation as Project Director. Prior to this, he was employed by Metro Glass Bottle Company in the Production Department.

HAZEL ATLAS APPOINTMENTS

J. H. McNash, President of Hazel-Atlas Glass Company, has announced changes in the company's sales executive personnel. John S. Algeo, formerly Vice President and General Sales Manager, was at his request relieved of responsibility and burden of directing the company's sales activity. Mr. Algeo, who is also a member of the Board of Directors, will continue as a Vice President active in its management.

To accomplish this change, J. H. Majesky, J. Nelson McNash and J. C. Neuhart, who have been associated with the company's sales activity for some time, were each elected a Vice President-Sales.

Also announced was the appointment of Robert G. Schaaf as Manager of the company's Cosmetic, Drug and Specialty Container Sales Department. William T. Otto has been named Manager of the Glassware Sales Department and Jack Hendrickson has been named Manager of the General Container Sales Department. All of these men have been associated with the company for some time.

• Glenn A. Hutt, Vice President of Ferro Corporation, was elected to a two-year term as President of the Porcelain Enamel Institute at its 23rd Annual Meeting.

Milestones in Glass Progress

PHOTO COURTESY CORNING MUSEUM OF GLASS

1770 The diamond-daisy pattern on this pocket flask was created by Henry Stiegel, one of the first American glassmakers. Decorated flasks of this type became the standard container for liquors in early America, and were made in a wide variety of designs. Most of them were blown in molds to insure uniform size.

1890 Michigan Alkali Company, now a division of Wyandotte Chemicals Corporation (South Plant, above), was founded by Captain J. B. Ford to supply Soda Ash to the glass industry. Wyandotte has grown up with glass. Today, as in the past, it is a working partner, supplying technical assistance and raw-material chemicals to those great companies marking milestones in glass progress.

Wyandotte
REG. U.S. PAT. OFF.
CHEMICALS
Wyandotte Chemicals Corporation, Wyandotte, Michigan
Offices in Principal Cities
Founded by a Glassmaker to Serve the Glass Industry

FIBERGLAS PLAYS MAJOR PART IN SOUND LABORATORY

Owens-Corning Fiberglas played a major role in the job when the General Electric Company undertook to eliminate "Little Sir Echo" in construction of its new $1,500,000 Sound Laboratory dedicated October 13 at Pittsfield, Mass.

The structure, which required more than a year to build, is designed to equip G-E engineers for studies of the sound of power transformers looking toward elimination of noise problems in that equipment. Major part of the laboratory is the anechoic (without echoes) chamber, which is about as high as a four-story building. More than 12,000 wedges of Fiberglas PF cover the walls, ceiling and floor of the chamber. Suspended six inches above the wedges covering the bottom of the chamber is a trampolin type floor, composed of interwoven 3/32 of an inch aircraft cable anchored on two-inch centers by 450-pound springs. The chamber is encased by walls five feet thick, made up of 12 inches of concrete, two inches of Fiberglas insulation, eight-inch concrete blocks, a layer of copper sheeting, dead air space and the Fiberglas wedges.

NATIONAL GYPSUM ELECTS OFFICERS

The Board of Directors of National Gypsum Company has announced the election of Fred A. Manske to the newly-created position of Executive Vice President, according to Melvin H. Baker, Chairman. One of several members of top management promoted by the Board, Mr. Manske will be in charge of the company's production, operations and sales.

Also announced was the election of Wells F. Anderson as Vice President in charge of Operations and Manufacturing, the position formerly held by Mr. Manske. William M. North was elected Vice President to assist the Chairman of the Board. Clifford F. Favrot, President of Carondelet Realty Corporation of New Orleans, was elected a member of the Board of Directors.

Mr. Manske, who is also a Director of the company, has been in the gypsum industry since 1923, and joined National Gypsum in 1934. Until his present appointment, he has been successively assistant to the Vice President in charge of Operations, Production Manager, Vice President in charge of Manufacturing and Vice President in charge of Operations.

Mr. Anderson joined National Gypsum as Production Manager in 1951 and was later made Vice President in charge of Production. Mr. North joined the firm in 1941 and has served as administrative assistant, assistant Secretary of the company, Secretary and General Manager of National Gypsum's Kansas Ordnance plant.

• Over 165 representatives of the glass and mirror industry attended the annual trade-wide dinner for the United Jewish Appeal recently held at the Hotel Esplanade and pledged more than $60,000 to the 1954 drive.

• George P. MacNichol, Jr., President of Libbey-Owens-Ford Glass Company, has been elected one of eight new trustees of the National Security Industrial Association.

In container ware batch
B_2O_3*
ANHYDROUS BORAX
ANHYDROUS RASORITE
BORAX—BORIC ACID
Speeds melting rate
Speeds fining rate
Improves durability . . . appearance
Container ware manufacturers are becoming increasingly aware of the merits of B_2O_3 as a minor constituent. A primary source of supply is the Pacific Coast Borax Co. with its continuous record of supplying highest quality boron compounds for more than fifty years. One single organization—from mine to refined product—assures top grade.
PACIFIC COAST BORAX CO.
DIVISION OF BORAX CONSOLIDATED, LIMITED
MANUFACTURERS OF FAMOUS 20 MULE TEAM PACKAGE PRODUCTS
NEW YORK • CHICAGO • CLEVELAND • LOS ANGELES

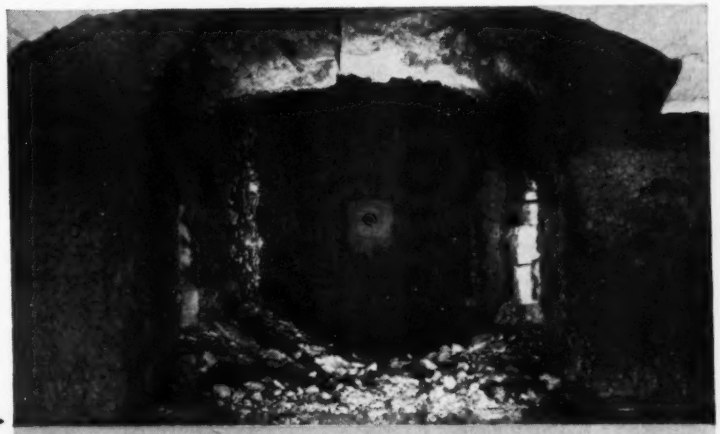
the trend is to

MONOFRAX®

FUSED CAST

refractories

WHEN PORTS LOOK LIKE THIS →



. . . it's time for MONOFRAX refractories. They have little tendency to flake or spall because of extreme resistance to heat shock, flame erosion and high temperatures. Chemically inert and practically free of interstitial glass, these blocks do not "honeycomb" nor drip into the molten glass. Eutectic formations, too, are largely avoided. These qualities help reduce refractory-caused stones and cords and extend block life.

MONOFRAX M REFRACTORY is the new, shortened designation for MONOFRAX MH *material. The composition of the refractory is unchanged. Practically pure alumina, it has an impurity content of less than 0.07%—the most nearly pure glass furnace refractory material produced.*

CARBORUNDUM

Registered Trade Mark

Dept. L-124, Refractories Div., Perth Amboy, N. J.

STRAINS AND TRANSFORMATION REGION . . .

(*Continued from page* 670)

The birefringence is either equal to the constant value when hot if the cooling did not disturb the structural equilibrium established at this temperature, or greater than the equilibrium value when hot if the transformation rate was not negligible in comparison with the cooling rate.

This study suggests two annealing processes in order to have glass without birefringence. If the refractive index value is of little importance, it is sufficient to bring the glass to the upper limit of the transformation range, and to leave it there about two hours so that it may acquire the state of equilibrium at this temperature (null birefringence).

The difficulty consists then in traversing the transformation range almost instantaneously in such a way that the glass will not have time to lose its state of equilibrium. Mme. Winter[4] succeeded in this by precipitating the glass in a pot of molten lead directly from the furnace. At room temperature, glass thus treated shows a null birefringence and a low refractive index corresponding to the fixed state at high temperature. This glass will be qualified as median annealing, sufficient in many cases.

If glass without strain and of maximum index is desired, the sample must be brought to a temperature close to the upper limit of the transformation range, kept at this temperature for the time necessary to acquire a state of equilibrium (null birefringence), then cooled at such a rate that it will follow the curve of state of equilibrium throughout the transformation range. The structural birefringence will be null since the glass will remain homogeneous during cooling. The only birefringence that can appear will be of thermal origin due to the cooling gradient. This will disappear when the temperature reaches the lower limit of the transformation range and the transformation rate becomes much lower than the cooling rate so that the temperature will be equalized in the entire bulk of the glass.

During cooling the refractive index passes progressively from the minimum value (fixed state at high temperature) to the maximum value (fixed state at low temperature). Below the transformation range the glass can be rapidly cooled without danger. The necessity of bringing the glass to a temperature close to the upper limit of the transformation range arises from the fact that at these temperatures only the structural birefringence of equilibrium is null. After cooling, the glass possesses its maximum refractive index, a null birefringence and a great stability. All these signs, a sure guarantee of its structural homogeneity, make for a fine annealing.

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(1) E. U. Condon, *Glass Ind., 33* (6), p. 307, 322, 323 (1952).
(2) B. Daragan, *Verres et Refractaires, 41* (2), p. 73/82 (1950).
(3) A. Lebedeff, *Comm. a l'Ac. des Sc. de l'U.R.S.S.* (April 21, 1948).
(4) A. Winter, Thesis *Revue d'Optique* (1938).

• "Automation", a word until recently considered by many as too fancy for practical use, has attained acceptance in the lexicon of industry. A survey conducted among engineers, technicians and industrial executives in 10 major industry groups for Minneapolis-Honeywell's Industrial Division found "automation" was the favored word of 82 per cent of those questioned when they sought to describe automatically controlled operations.

INVENTIONS AND INVENTORS . . .

(*Continued from page* 676)

ber 22, 1950. Issued April 20, 1954. Five sheets of drawings (none reproduced). Assigned to American Optical Company by Robert B. Barnes and Walter A. Fraser.

Improvements in television glass are cited which provide controlled absorption characteristics as to visible and invisible portions of the spectrum, as well as injurious rays such as ultraviolet and X-rays.

The following table lists the ingredients which may be used in producing desired characteristics:

Ingredients	Amounts, per cent
Silica (SiO_2)	60-72
Boric oxide (B_2O_3)	0-7
Soda (Na_2O)	14-20
Potash (K_2O)	
Lime (CaO)	9-11
Lead oxide (PbO)	
Titania (TiO_2)	0-5.0
Vanadium oxide (V_2O_5)	0-0.15
Cerium oxide (CeO_2)	0-5.0
Manganese oxide (MnO_2)	0-1.4
Nickel oxide (Ni_2O_3)	0-0.01
Cobalt oxide (CoO)	0-0.003
Copper oxide	0-0.4
Silver oxide	0-0.3

To the batch ingredients are added suitable fining agents, such as antimony oxide, arsenic oxide or sodium-chloride, in an amount ranging approximately from .5% to 2%, and the oxides of vanadium, cerium, titanium, manganese, nickel, cobalt, copper and silver are included for controlling the resultant color and ultraviolet absorbing characteristics.

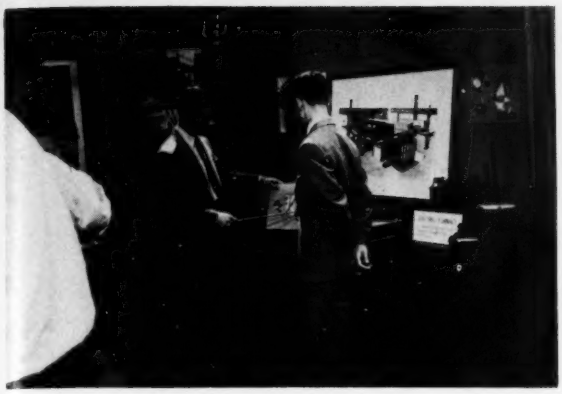
The patent contains 14 claims and the following references were cited: 667,646, Bergier, Feb. 5, 1901; 1,292,-148, Taylor, Jan. 21, 1919; 1,726,635, Taylor, Sept. 3, 1929; 2,143,022, McClure, Jan. 10, 1939; 2,219,122, Weidert et al., Oct. 22, 1940; 2,282,601, Blau, May 12, 1942; 2,582,453, Pincus, Jan. 15, 1952; and 11,019, Great Britain, 1888.

T. A. HASCHKE OF STAUFFER CHEMICAL DIES

Theodore A. Haschke, Director of Sales of the Industrial Chemical Division of Stauffer Chemical Company, died on October 5 at the age of 56. Mr. Haschke was also a Director of the Old Hickory Chemical Company.

Mr. Haschke, a native of Texas, entered business as a salesman for the Round Rock White Lime Company in 1919. He joined Stauffer as a salesman in Houston, Texas, in 1926 and was transferred to New York six years later. He was named Sales Manager of the company's Eastern Division in 1942, a post he held until his most recent assignment in January of this year.

• Several hundred members of the American Society for Quality Control, together with members of the country's industry who are interested in the Science of Quality Control, gathered in Dallas, Texas, on November 18 and 19 for their Annual Ninth Midwest Quality Control Conference.



A.C.S. SECTION TV SERIES

On October 31, the Northern Ohio Section of the American Ceramic Society presented its third television program in a series entitled, "Adventures in Engineering and Science". This series of programs was undertaken by the Cleveland Technical Societies Council as a means of informing high school students of the opportunities available to them in science and engineering.

The program just completed, "Harnessing Heat", was directed towards explaining refractories and the activities of the ceramic engineering in the refractory industry. The active participants from the Section were Frank Newark, Alcoa, Charles Greenlee and Niel Meredith, Basic Refractories, Inc., and Yung Tao, North American Refractories Company. Previous programs were devoted to ceramics and the ceramic engineer, and the porcelain enamel industry.

INDUSTRIAL DIAMOND HANDBOOK

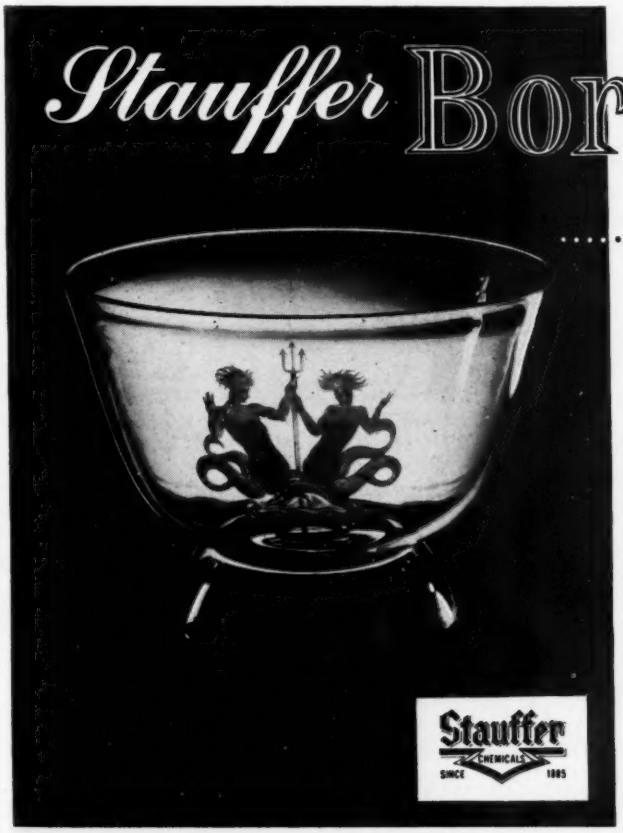
The Industrial Diamond Association has announced publication of an Industrial Diamond Association Toolshank Handbook. It is in loose-leaf form, 5½ x 8½ with enclosed binder.

The purpose of this handbook is to have under one cover an indexed assembly of diamond dressing tools with drawings and specifications, and to further the efforts of the Association to reduce the types of shanks to the lowest practical minimum. The 32 pages of drawings and 5 pages of index represent about 90% of the diamond tools being used for the trueing and dressing of abrasive grinding wheels.

KAISER APPOINTMENT

Kaiser Aluminum & Chemical Sales, Inc. has announced the appointment of William Hanahan as a senior sales engineer in the Chemicals Division. He will represent the Division in Michigan, Ohio, Northern Kentucky and parts of Canada, and will establish his home in Detroit.

Mr. Hanahan joins Kaiser Aluminum with 12 years experience in the metals field, including four years as open hearth practice man and foreman with Kaiser Steel Company, his most recent position. A graduate of Illinois Institute of Technology, Mr. Hanahan served as a chief boatswain in the U. S. Merchant Marine during World War II.



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*Trade mark of West End Chemical Co., Stauffer Chemical Co., sole distributors.

G.C.M.I. MEETING . . .

(*Continued from page* 63)

On the social side, and despite rather cool weather in the rarefied air of Colorado Springs, there was plentiful competition for the many attractive golf prizes. The ladies card party also offered some very desirable prizes and was its usual success, as was the delightful cocktail party hosted by the West Coast members. The final social event was the Institute banquet which was enjoyed by everyone.

CORNING MANUFACTURES 300-MESH GLASS SCREENS

The successful manufacture of 300-mesh precision glass screens containing over 200,000 square holes so small they cannot be threaded by a human hair has been announced by Corning Glass Works. Currently being supplied for use as part of a cathode ray tube, the precision screens can now be made more accurately than ever before.

Prior to the use of glass, these components were usually made of copper by an electroplating process. The new glass screens offer sharper definition and at the same time simplify manufacturing and conductivity problems encountered with other materials.

The screens are currently being supplied as small squares with approximately 2¼ square inches of screen area containing 90,000 accurately spaced holes per square inch. However, the unusual manufacturing method is not limited to these sizes or shapes or to 300 mesh.

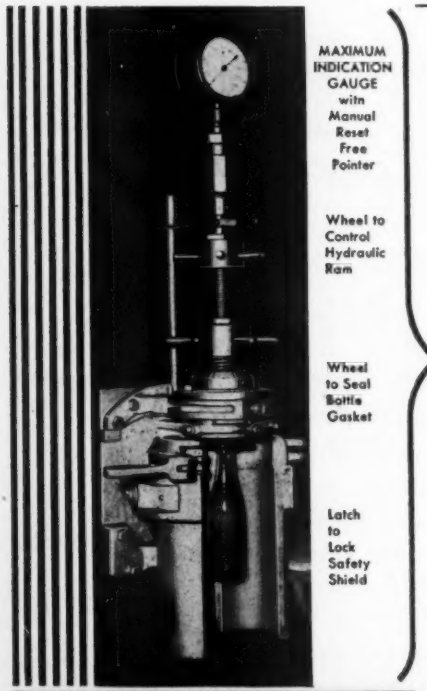
The screens are being made from Corning Fotoform glass, a new photosensitive glass that can be formed and cut with photographic precision. After the screen has been formed, the glass is converted to Fotoceram, a material two to three times stronger than the parent glass. The process can be adapted for partial or complete cutting of glass in any pattern that can be reproduced photographically.

DIAMOND ALKALI GETS MUSCLE SHOALS PROJECT UNDERWAY

The first step in getting the Muscle Shoals Chlorine-Caustic Soda plant of Diamond Alkali Company into production by January 1, 1955 was taken as the company awarded a contract to Leonard Construction Company, Chicago, for rehabilitation and construction of certain additions to the plant and equipment.

In making the announcement, Steve Puschaver, Plant Manager, said that the contractor plans to start tomorrow to recruit employees at the plant site to get this construction project underway as quickly as possible.

Recently purchased by Diamond Alkali from the government, the Muscle Shoals plant was built by the Leonard firm in 1950-1952 to meet an anticipated chlorine shortage as a result of the Korean crisis. When the shortage failed to materialize, the plant was maintained in standby condition. Declared "surplus property" by the government late last year, it was purchased by Diamond in October.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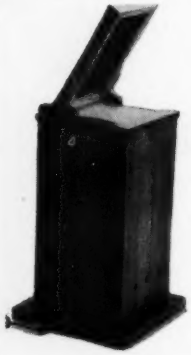
RESEARCH DIGEST . . .
(*Continued from page 677*)

while from the ridges between flows the protective solution. After a while, with enlargement and coalescence of the holes, consequent lengthening of the flux-line periphery and derangement of the periodicity, changes in temperature and so on, individual pits become obliterated leaving a groove at the glass line. As the glass level falls, there is formed on the lower ledge of this groove a new series of pits.

Close pitting of the pot bottom occurs with dense glasses of small surface tension. It is quite common with high-lead glass without any metallic lead separating. On account of its greater cohesion, the aluminous solution adhering to the bottom of the pot gathers into blobs. This aggregated solution, because of its low density, rises into tongues much as a soft parison is drawn into a rod. Counter-currents of denser penetrating solvent descend between the tongues and wear holes where they impinge on the bottom. The viscous film formed on the refractory surface inside the holes is continuously dragged into the main web of solution guarding the rest of the bottom. There is a circulation of glass down the middle of each hole and upwards from the ridges between. As each hole deepens, the vitrostatic pressure differences between solvent and solution increase, thus reinforcing the downward jets scouring the bottom. With dense glass in a refractory pot, there is lighter solution against the sidewall. This results in a slow current which flows down in the interior of the pot, then round and up against the side. The downward streams of solvent are thus intensified and diverted outwards, thereby accounting for the piercing of pot bottoms at or near the corner of the pot.

When glasses are melted under reducing conditions, heavy metals like gold, silver, copper, lead, tin, nickel, cobalt, even iron, or their alloys, may separate and sinking to the bottom will penetrate the protective layer of aluminous glass and gather into beads. If there is any appreciable quantity of oxygen dissolved in the beads, this may give corrosive metal oxide or by escaping as gas cause teetering. Downward streams of penetrating corrosive solvent envelop the mobile metallic beads as they grow, dance and turn. This solvent, together with any small pick-up of metal oxide, then attacks the refractory beneath. The aluminous solution formed is extruded by the heavy beads and frequently rises upwards, encouraging local circulation. An analogous phenomenon is upward drilling by gas bubbles such as occurs on the underside of rings, floaters and throat blocks.

Another striking and distinctive type of contour, again etched beneath dense glass of small surface tension, is a close and regular downward scoring on an ascending refractory face and is very marked on the underside of a sloping refractory block. Again an explanation is to be found in the differences between solvent glass and the aluminous solution formed at the refractory surface. Because of its greater cohesion, the less dense aluminous solution, slowly rising up the underface of the inclined block, gathers into filaments which move upwards side by side. Dense penetrating corrosive solvent glass, including that creeping down the face from the flux line, passes between the rising filaments and eats narrow channels in the refractory. The viscous film formed along the bed of each channel is continuously drawn by cohesion into the



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threads that are formed on either side.

The pitting and scoring described depend on differences between solvent and solution. In industry, such detailed patterns are often masked due to the many variables such as texture and firing of the refractory, corrosion, erosion and abrasion by batch, evolution of gas, foam and gall floating on the glass, glazing of the wall above the glass line by dust and vapor, changes of glass level and temperature differences. However, surface forces are still persistently helping to wear away refractories.

NORTON TO BUILD NEW PLANT

Norton Company will add to its electric furnace capacity by building a new plant in Huntsville, Alabama, according to an announcement by Milton P. Higgins, President.

This expasion of Norton's electric furnace facilities will be situated on a 100-acre site in an area known as Hobbs Island along the north bank of the Tennessee River. Ground will be broken late this year with completion expected by the end of 1955. Total cost of land, buildings and equipment is estimated to be $1,250,000.

• A conference on silicosis and occupational chest diseases, jointly sponsored by the McIntyre Research Foundation of Toronto, Canada, and The Saranac Laboratory of Saranac Lake, New York, has been arranged for February 7, 8 and 9, 1955 in the Town Hall at Saranac Lake.

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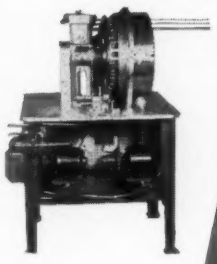

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LARGEST ALL-GLASS TANK COMPLETED BY PPG

One of the largest, free-standing, all-glass tanks ever built has been completed by the Pittsburgh Plate Glass Company, according to George West, Manager of Structural Glass Sales. This tank, constructed for the Detroit Municipal Aquarium, is 9 feet long, 4 feet deep, 2 feet wide and holds 540 gallons of water. It is made of heat-tempered glass (Herculite) for added strength and durability held securely in position by brass rods.

NEW LAMINATION PROCESS

The development of a central adhesive colored core, which is thin and stable, has made possible the manufacture of a new type of color panel, according to an announcement by Marks Polarized Corporation, Whitestone, Long Island, New York. The process of manufacture is called "microlamination". With this process, according to the originators, a wide variety of colors may be held to close tolerances. Made in 10″ x 10″ size in all standard glass thickness combinations, the colors meet the requirements of instrument makers and the photographic industry.

Uses of the new Microlam color panels include ultraviolet absorbing and infrared absorbing. Colors include neutral density, yellow, violet, orange and red in all shades and densities. Special colors can be made. Through the process, polarized panels up to 12″ x 12″ are being made to fill a variety of uses, such as strain testers for glass structures, glare reducing shields, variable density filters for controlling optical density.

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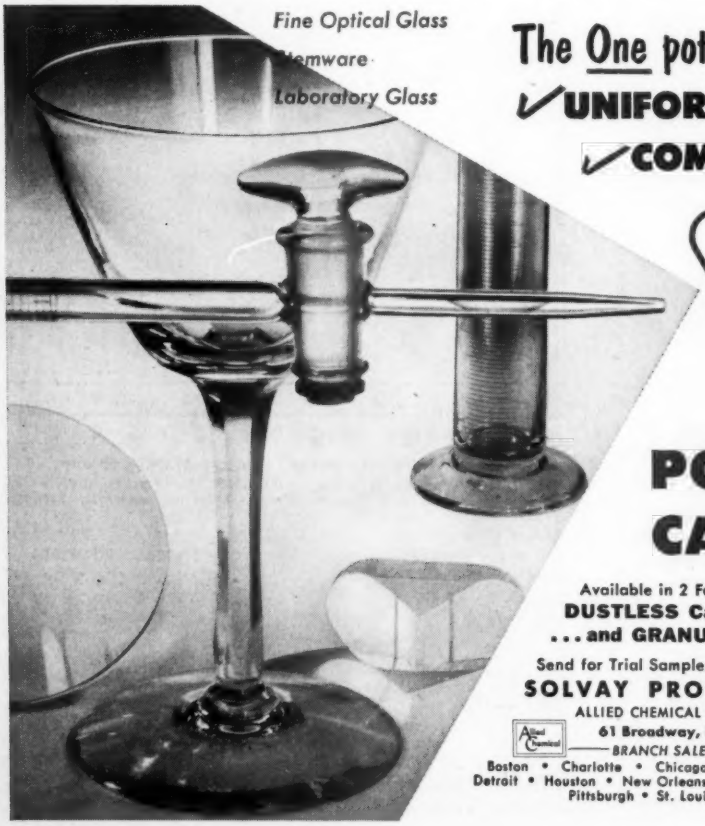
GLASS INSULATORS

Tempered pin-type glass insulators manufactured by Kimble Glass Company, subsidiary of Owens-Illinois Glass Company, were recently accorded final acceptance by the Rural Electrification Administration of the United States Department of Agriculture. Recommendation for final acceptance was made by the R.E.A. Technical Standards Committee "A", and the insulators are now added to the list of materials acceptable for use on systems of R.E.A. electrification borrowers.

• The United States Gypsum Company has been named the best managed company in the stone, clay and glass products industry by the American Institute of Management. The 34 companies heading their respective industries have rated the highest number of points achieved by any company in their industry, achieving at least 7,500 points out of the possible 10,000 under the Institute's method of evaluation for ten categories of management function.



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